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The Advantages of Meat in Pregnancy and Lactation Again Affirmed

The need for an augmented protein intake during pregnancy and lactation has long been known. In a recent controlled study,* the value of increasing the protein consumption during the last four months of pregnancy and the first three months of lactation was again demonstrated. The subjects were instructed to "eat plenty of meat—a generous serving at least twice a day." The average protein intake was augmented by 5 ounces of meat supplied daily to each subject.

Careful observation disclosed that the women receiving the larger meat ration "had consistently better hemoglobin and red cell values at all times than did their experimental partners who received either B complex or no supplement." Furthermore, the group receiving the extra meat showed less edema, had better success at lactation, and felt better than they did during previous pregnancies.

Thus the value of meat as a source of protein in pregnancy and lactation is again affirmed. Containing all the essential amino acids, meat satisfies all protein needs.

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*Leverton, R. M., and McMillan, T. J.: Meat in the Diet of Pregnant Women, J.A.M.A. 130:134 (Jan. 19) 1946

The Seal of Acceptance denotes that the nutritional statements made in this advertisement are acceptable to the Council on Foods and Nutrition of the American Medical Association.

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"HITS, STRIKES AND OUTS" IN THE USE OF PEDICLE FLAPS FOR NASAL RESTORATION OR CORRECTION

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THE purpose of this paper[1] is to illustrate some of the underlying factors that can make either for success or for failure in the substitution of skin-bearing flaps for lost or lacking nasal tissue. Such flaps may be used alone or supplemented with cartilage implants or free skin grafts. The need for nasal restorations or corrections might come from (1) congenital absence (total or partial), (2) postnatal growth irregularities, (3) tissue loss through disease, accident, or surgical destruction.

PREOPERATIVE CONSIDERATIONS

The quality of final outcome and number of operative steps required may be more closely related to the thoroughness of preoperative study and planning than to the skill expended. In complex cases, it is worth while to check repeatedly the tentative plan, otherwise some oversight might necessitate a midstream modification, causing delay, increased operative steps, and ultimate disappointment. Disappointment is not helped by the feeling that more persistent preoperative study might have prevented the debacle.

This survey should compass not only the tissues of the external nose proper and the sources and kind of repair material available, but also the condition of the foundation tissues (Figs. 7, 11, 18, 26) and of the nasal passages (Figs. 5, 8, 9, 15). The latter is unfortunately often missed. Fitness and fit are as essential here as in the foundation of a house. The proper time for securing these is before and not after the nose or the house is added. Therefore, before considering the external nasal repair, the underpinnings, breathing space, and the usable nasal remnants should receive careful scrutiny. Loss or displacement in the nasal framework or of the related cheek, lip, columella, or septum should also be determined (Figs. 5 and 16.) When present, correction of such loss or displacement should be at least visualized before the nasal repair is planned. Restoration of the foundation and repositioning of tissues to give breathing space are parts of one problem; selection, patterning, and transplantation of repair material are parts of another problem. These two must at least be correlated mentally before surgery is undertaken.

Recorded sculptors of less skill than Phidias all preferred to materialize their ideas in clay before risking a false cut on a marble block.

Presented before the American Association of Plastic and Reconstructive Surgery, October 7, 1943.

Bernard G. Sarnat, M.D., assisted in assembling the material for the case histories.

For camouflage and emphasis the greatly reduced prints in the figures have been appropriately blanked and penciled but without intentional sacrifice of lines of verity.

[1]This study is based on selections from considerably more than a hundred flap restorations.

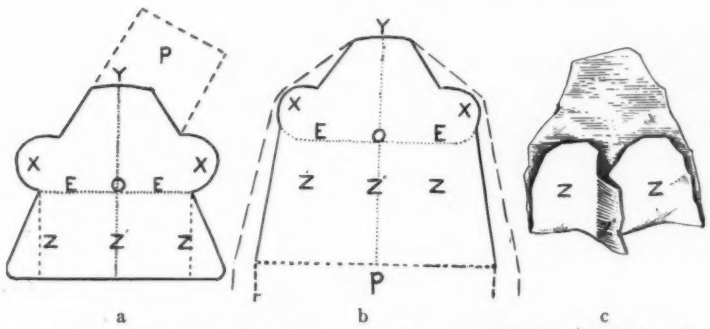

Fig. 1a, Diagram of a forehead flap. *Z*, *Z'*, *Z* is for vestibular lining and columella. Lateral dashed lines (*Z*, *Z*) on the lower part show the minimum width of forehead flap for vestibular folding. Dark outline shows desirable width, often available in men with receding hairlines. Making dorsal covering and vestibular infoldings with adequate airway from a forehead flap less than 5 centimeters wide can be difficult. *X*, *X*, alae; *O*, site of tip of nose; *Y*, glabella; *P*, pedicle.

b, Diagram and plan for infraclavicular flap, whether arm or body, applicable where sufficient bone or cartilage remains to give form to the new nose (Fig. 18). Observations of graft-lined flaps suggest that with no supporting framework available for an arm flap, patterned after the outer dashed line of *b*, the covering part, previously thinned and lined with a contracting split skin graft, should fairly well hold its form when sutured to a scar-fixed bed. Later the excess graft lining the vestibular part would be removed to accommodate the infoldings. Whether neck, trunk or arm, the pedicle comes from below. Note greater allowance for length of *Z*, *Z'*, *Z*. The pedicle-infolding part of the flap should be between 9 and 11 cm. across. (5,b)

c, Diagram for a foil model of the plan of the vestibular folds regardless of whether the pedicle is above or below. *Z*, *Z* shows the part of the infold used for vestibular lining. *Z'*, the mesial abutment from which the columella was made.

SERIES A. GROWTH CHANGES IN TRANSPLANTED FLAPS

In this series of cases, teen-age or younger, some useful comparisons can be made of growth changes in early repair. Disregarding the disparity of ages, an apt comparison can be made between the case in Figure 2 and that in Figure 3. Though the losses were similar, the former was repaired with a forehead flap and the latter with an arm flap.

The relation of size to growth of a nose made with a forehead flap will remain more stable and with an arm or subclavicular flap will be rather stable if the major part of the supporting structures has persisted intact. Figure 4 presents a case in which the estimated allowance for growth proved insufficient.

In a growing nose with vestibular lining and covering derived from foldings of the same flap, the similar growth impulse may in time cause vertical wrinkling of the confined lining layer, as can be seen by comparing *e* with *f* in Figure 3, where repair was made from an arm flap. This was less evident of the forehead flap repair in Figure 2, as shown by the photographs taken 3 years after final operation in each case.

In Figure 5, e, repaired with a forehead flap, done at a much later age, the disproportionate changes with growth are less evident. At no stage was there wrinkling of the vestibular lining. Figure 5 shows also that even in the use of a forehead flap, it is necessary to make allowance for some shrinkage emphasized by the change in shape of the ala and tip in 2 weeks' time (compare g with h).

Regarding the cases in Figures 6, 7, and 8 showing congenital infection, the common characteristics were faulty development of the supporting tissues with active snuffles or ulceration in the lining. Restoration of the nose, shown in Figure 6, was made with little bone or cartilage support but allowance was made for growth and possible later cartilage implantation. This accounts for the marked dorsal convexity of the completed nose. In Figure 7 the child originally had almost no supporting framework, lacking even columella and premaxilla. In Figure 8, the restoration of the nose was closely bound up with that of the lower lip.

Fig. 2. A girl, 10 years old, with destruction following surface radium applied at 5 weeks of age, condition shown in a and d. b, Primary application of a forehead flap. The foldings for alae and columella here shown were readjusted shortly afterward to give better breathing space. c and f, Photographs sent to us approximately 4 years after application and adjustment of the flap. Comparing e with f shows that the right alar border has become lower than the left, but this could, even now, be readjusted. Seven operative steps, major or minor, were required over a period of 3 years.

Fig. 3. A girl, 15 years old, had received destructive radiation in infancy. a and d, Show condition with wide scarring of the lower third of the nose and related columella. b and e, Condition 4 months after surfacing the nose and restoring the vestibule with an upper arm flap. c and f, Photographs taken approximately 4 years after final adjustments.

It is difficult at this time to determine whether all of the shortening shown in f is real or partially due to some uptilting in the pose of the photograph that was sent to us.

Five operative steps, major or minor, were done in less than two years.

Fig. 4. This supersensitive child was 8 years old when repair was initiated. Early arm flap repair failed to keep

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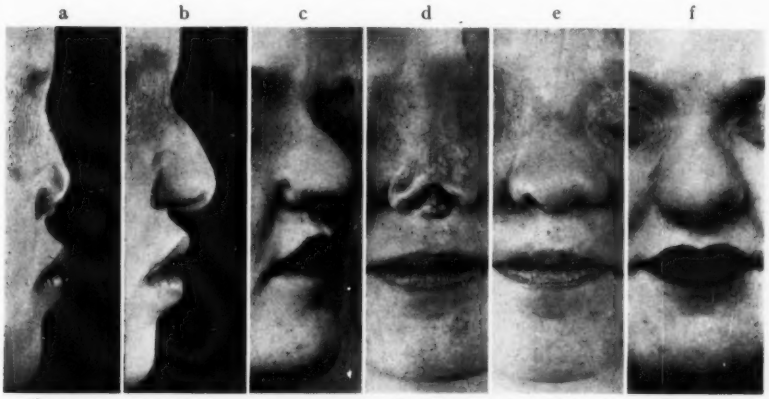


Fig. 2.

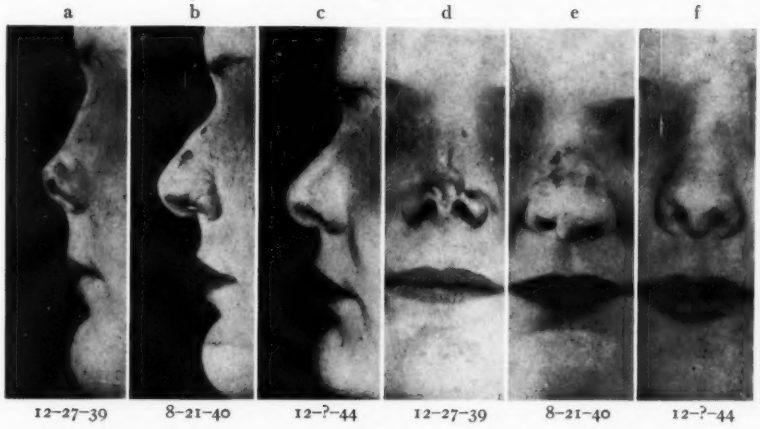
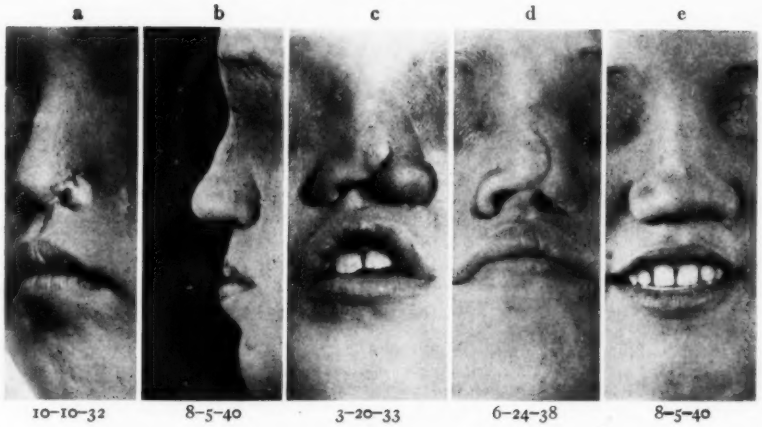


Fig. 3.



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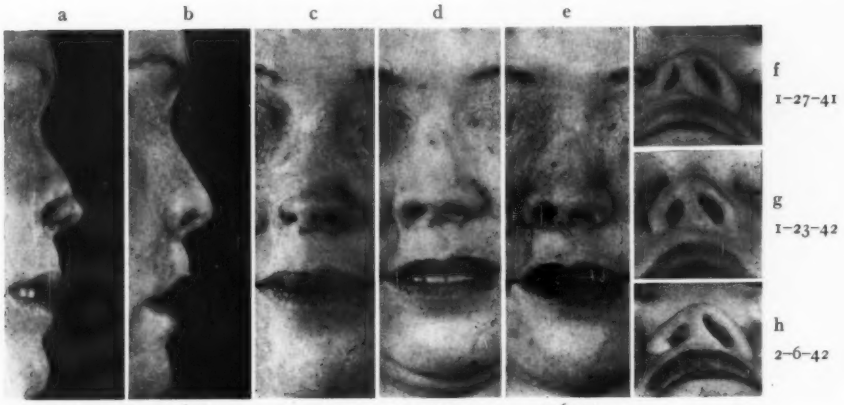

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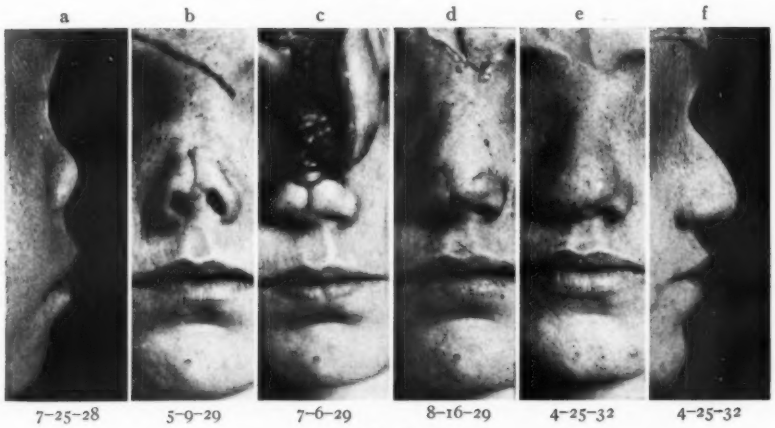

Fig. 6.

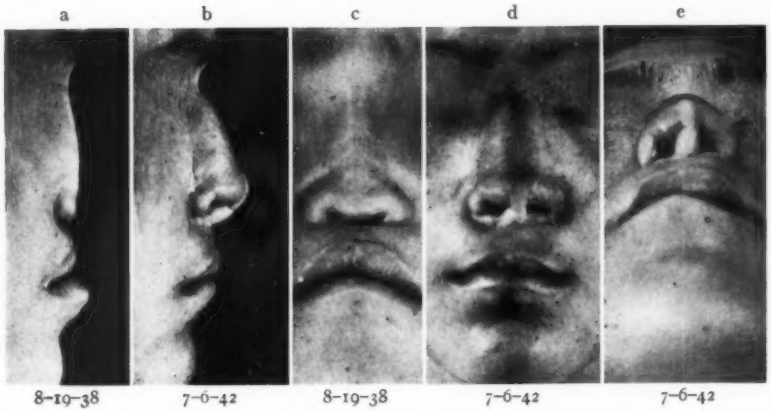

Fig. 7.

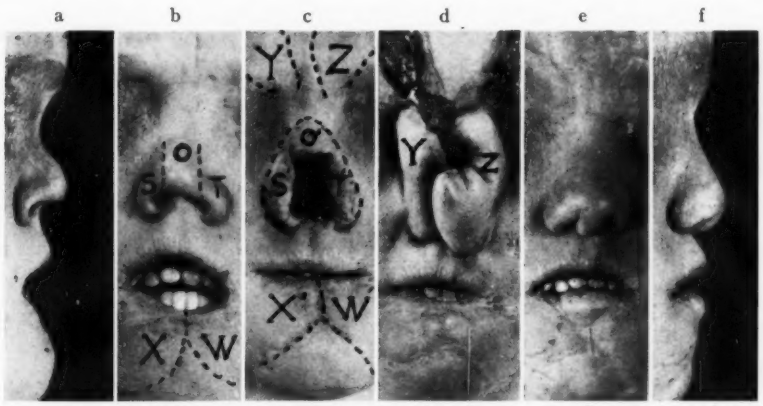

Fig. 8.

pace with nasal growth. a, Shows radium destruction in infancy, causing scarring and crumpled ala. c, After excision of damaged tissue, sufficiently extended to insure circulation in the transplant, an oversize flap was implanted in the belief that it would provide for future growth. d, Five years later, the above allowance for growth had proved insufficient. At this time the original flap was removed and the distortion was released. An abdominal flap was "jumped" via the left hand and adjusted. b and e, Photographs taken 2 years after final repair. Twelve operative steps, major or minor, were done over a period of 8 years.

The new nose is not central in its relation to the lip or the teeth.

Fig. 5. A girl, 17 years old, was injured 9 years previously. a, c and f, Photographs show adjacent partial nose and cheek loss with incidental alar distortion and vestibular block. The skin graft on the upper lip had been applied shortly after injury. d and g, Taken 1 year after covering the right half of the dorsum with a forehead flap infolded to line the vestibule and piece out the ala. The intentional exaggeration of the alar circumference of the vestibule still shows. Gravity was expected eventually to correct the draw-up of the new alar border. b, e and h, Show final adjustment of cheek scar, alar attachment, and symmetrical shrinkage of the alar circumference, but the alar border is still above the level of its fellow.

This required eight operative steps, major or minor, over a period of 1 year.

The alar draw-up cited persisted.

Fig. 6. Congenital deformity in a girl 10 years old. a and b, Condition at first examination. After release of the uptilt, repair was made with a right forehead flap, with a pedicle at the left brow, wide enough to supplement both lining and covering, shown in c. d, The covering part of the flap is in position with a prolongation between the separated alae to piece out the tip. e and f, Last observed result, 2½ years later. This was done in six operative steps, completed in 3 months.

Subsequent growth will likely modify the convexity of the dorsal line.

Fig. 7. Congenital deformity in a girl, aged 12 years. a and c, Show the condition with the lip repaired and a cartilage previously inserted in the upper two-thirds of the dorsum. b, d and e, A flap from the right lower abdominal quadrant was jumped via left wrist to the dorsum after removal of the nasal covering and the lower part of the original cartilage implant. Later the columella came from an inner lateral palm flap implanted first into the nasal tip and subsequently into the lip, b and e. Owing to circumstantial delays, the 18 major and minor operative steps were spread over a period of 4 years.

Fig. 8. A girl, aged 17 years, with history of premature birth, reported weight 1½ pounds. Congenital infection with early ulceration of lips and nasal lining. Left vestibule almost obliterated, columella retracted and much of lower lip missing, a and b. b, The two vertical lines between *s* and *t* indicate full thickness incisions which, after discarding the scarred lining and the related cartilaginous septum, permitted the turning in of the skin to furnish attachment to the future lining flaps, *s'*, *t'*, *o'* in c. *X* and *W* indicate full thickness flaps (8, b). In c, flaps *X'* and *W'* have been rotated to give vertical length to the lip. *Y* and *Z* indicate primary raising of the nasal flaps. d, The nasal flaps *Y* and *Z* were again raised, the distal two-thirds of each thinned, doubled back and fixed with sutures to heal, raw to raw, to help piece out the vestibular lining.

The nose, as shown in e and f, was accomplished by turning in *s'*, *t'*, *o'* as partial lining, attaching the nasal flaps *Y* and *Z* sutured in the midline. The columella came from some extra width on the mesial border of *Z*, originally provided for that purpose. We have several times used this double flap where the forehead was wide but too low to furnish it in one piece (Fig. 32). The dorsal line of junction can, with careful cutting and suturing, be made all but invisible. Where a nose is patched with an arm flap, the line is apt to be evident, less so if enough material was provided to allow a secondary adjustment.

e and f, Show the final result. At recent steps a crescent piece was sawed from the mandible to shorten the vertical chin-lip length. Later the two halves of the lip were separated. A folded arm flap was implanted into the midpart to give more than double the transverse width of the previously tight lower lip. At the time of transfer, the rolled edge was left overfull to permit later an attempted reproduction of the natural slight ridge of the mucocutaneous junction.

This was accomplished in 18 major or minor steps done in 5½ years' time.

A wider insert would have avoided the slight "V" at the right border.

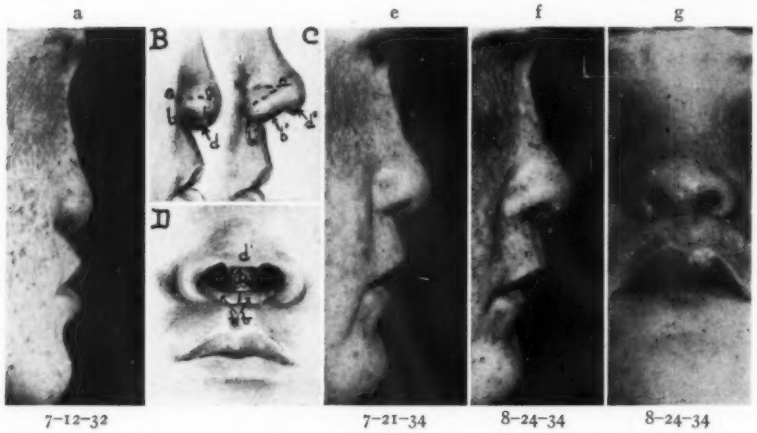

Fig. 9.

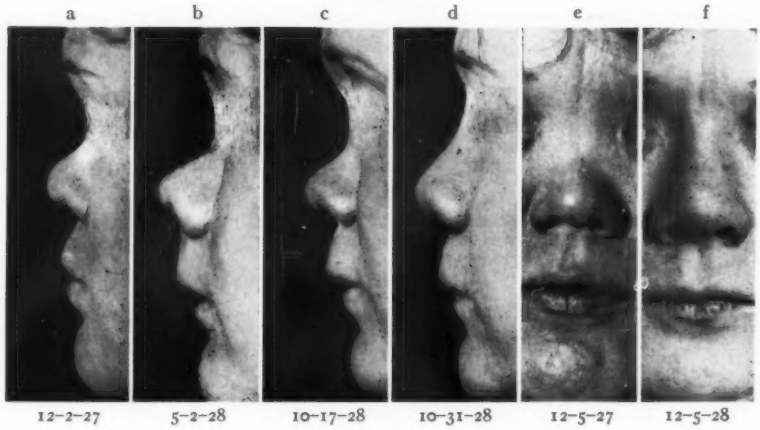

Fig. 10.

SERIES B. DEFORMITIES INCIDENTAL TO A SHORT NASAL TUBE

These deformities might be congenital, as in Figure 9, or due to infection, as in Figure 10, or acquired in growth, as in Figure 11. In some, correction might necessitate synchronous lengthening of the nasal covering (Fig. 11).

Fig. 9. a, Girl, aged 12 years, with columella and vestibular floor short, but with full vertical length of the dorsum. Correction required several very distinct steps. The first was accomplished by dividing the short columella from the lip and septum. This nubbin of columella was fixed in an advanced position, shown in b. In b, *a-a* roughly indicates a lining incision that traversed the floor of the vestibule and extended well forward in each lateral wall. *b-b* indicates the lower border of the ala; *d*, the original position of the columella. c, Wide undermining permitted the border and lower part of the alar covering to be moved downward and forward, with the resulting lateral defect in the lining, indicated by *a'-a'-a'*, while the liberated stump of columella was moved forward to *d'*.

d, The lining defect was filled in with the two halves of a "swallow-tailed" lateral palmar flap, introduced through the nostrils. After circulation was established, the pedicles, *f-f*, were divided in the midline of the floor. The columella was later pieced out from the remaining palmar pedicle. *e*, indicates the bared lower border of the septum.

e, Shows the result of these implantations but which have not as yet brought the nose or lip sufficiently forward. To correct this, the new columellar patch was freed from the septum, the lips and cheeks were freed from their intraoral attachments by incising in the depth of the upper sulcus, and with the columella were sutured in a further advanced position, the circulation in the columellar patch being maintained by its anterior and posterior attachments. f and g, Show the final advancements and the columellar patch.

This was done in seven operative steps, which for extrinsic reasons were extended over 2 years.

Fig. 10. A woman, 28 years old, had a flat bridge since childhood with history of ulcerations and repeated treat-

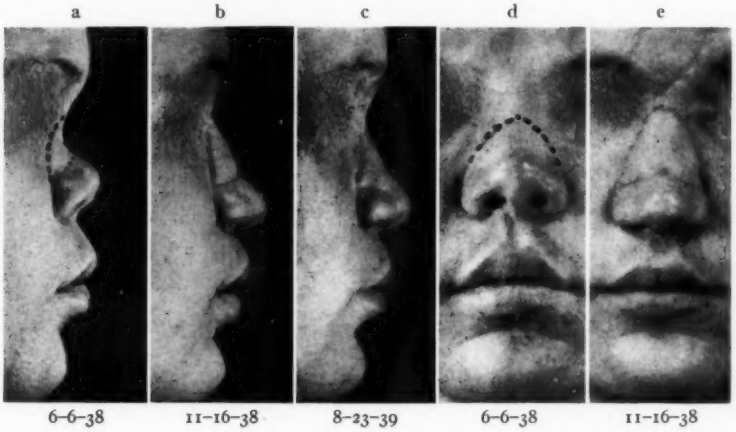

Fig. 11.

ments. a and e, Show saddle nose and loss of vestibular lining, but dorsal covering and columella of sufficient length; short nasal tube. Disregarding the presence of the columella which was lacking in Figure 9, the plan of lengthening of the vestibular floor and walls is identical with the exception that in Figure 9, d, the "swallow-tailed" flap was introduced through the common nostril space while in this case it was introduced sublabially.

b, Shows the immediate result of the tubal lengthening which for lack of cartilage support was but partially maintained in the healing process (see c), but a secondary undermining of the dorsum and the implantation of cartilage gave the result shown in d and f. The above procedures give about the limit of lengthening solely by additions to the lining. This was accomplished in 7 operative steps, major or minor, over a period of 15 months.

Fig. 11. Faulty postnatal development with shortening of both the dorsal line and the nasal tube, in a man, 21 years old. a and d, Here the approach was through an external incision, as indicated by the dashed line in a. The superficial tissues were stripped as far down as the dotted line, at which level the alae, cartilages and floor of the vestibule were cut across. The lower part of the septum and the related soft tissues were mobilized as in Figure 10. In Figure 10 the lining flaps were entered from below, met at the dorsum and were wedge shaped. In this case, the lining flaps entered through the dorsum and met at the midline of the floor, were cut across at the dorsum, square-ended both above and below. The covering flap in, b, came from farther up on the pedicle. Later developing scar constrictions were dealt with through the nostrils; the need for the latter is less frequent after implantation of a forehead than of an arm flap. b, Shows the condition several months later. c and e, Views of the final result, show the dorsal line brought forward, accomplished by surface readjustment and dorsal implantation of costal cartilage. Four years later airways were reported satisfactory. A total of 7 operative steps was done in 1 year's time.

Split graft in forehead could be replaced with pigment-injected full thickness graft.

Human flap material is precious. The surgeon will best serve the patient and himself by first making patterns from plaster-clay restorations of what he is attempting to re-establish (5,a). One that does not exaggerate the surgical possibilities serves as a usable working pattern, helps the patient to visualize better the aimed-at result, and gives some idea of the intricacies involved. Even then it is hard to gauge the patient's buoyed-up expectations. It is good practice to hazard the remark that the operative result will, most likely, fall quite a bit short of the model—unfortunately often true. In faces both operated upon and not, the natural color and mobile expression will camouflage moderate defects in contour, which on the white cast stand out glaringly (9).

FLAPS

There are three general sources from which the flap might be taken, directly or "jumped": (1) the hair-free regions of the forehead and face; (2) the arm, hand, anterolateral areas of the trunk and the groin; (3) pedicle flaps derived from the nose (Figs. 1, 27, and 29). Of prime importance in the selection of tissue for a flap is the recognition of variations in the suitability intrinsic to the donor area. The outstanding characteristic of those taken from above the mandible is quality, from below the clavicle is quantity. In hair-free areas of the neck those factors merge, but with quality still dominant (Fig. 17). A more detailed but terse differentiation of aptitude is given in Table I.

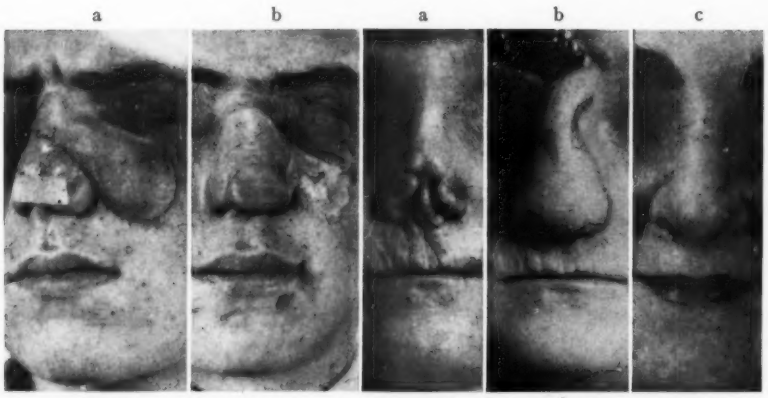

Fig. 12.

Fig. 13.

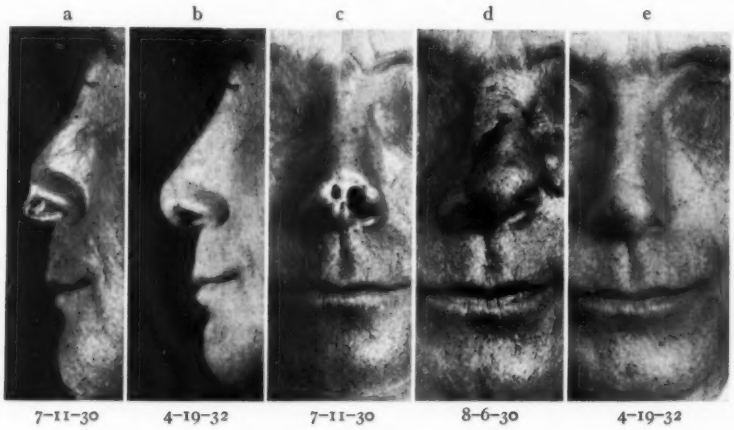

Fig. 14.

SERIES C. DESTRUCTION IN THE TIP AREA OF THE NOSE

In cases of this type, establishment of breathing space is usually an essential step. The main flap can be taken from the arm, forehead or neck, or jumped, while the lining may be supplemented by a flap from the dorsum. Cartilage implantation may be necessary.

Fig. 12. Traumatic loss of tip of nose, 1 month previously, in a man 18 years old. a, Flap was outlined laterally and undermined but the distal end was not detached. On account of poor circulation, two more operative steps were required before it was considered safe for transfer. A piece of adhesive covers the missing tip in, a. Three more operative steps were necessary. b, It required one switching, two adjustments and a postaural skin graft on account of a poor circulation which threatened a loss after each operation. This difficulty of establishing a circulation is extraordinary for a face flap. In the case in Figure 14, the age of the older man may have been a factor in permitting the raising and implanting and replacing of the pedicle of the flap at two steps.

Fig. 13. Between the age of 3 months and 3½ years, patient had ulcerations of undetermined cause. a, Shows condition at our first examination of the girl, 8 years old. b, Forehead flap was put down in place. This was followed by the usual adjustments. c, Patient returned 10 years later. Batwing operation was done to bring forward the tip of the nose and a split skin graft covers the original lip scars. This required four operative steps in all.

Fig. 14. a and c, Loss of tip of nose from cancer paste, in a man 52 years old. A triangular flap was raised from the left cheek with the base at the bridge of the nose and was transplanted immediately into the defect, d. We cut and adjusted pedicle on nose and in cheek, using skin graft to fill out latter. b and e, Taken 20 months later. This man had a loose, very movable skin with almost no underlying fat, which three factors seemed to warrant the successful attempt to complete the operation in two operative steps. Compare this with case in Figure 12.

There is room for judgment in each case, but the success here hardly warrants repetition of the two-step operation.

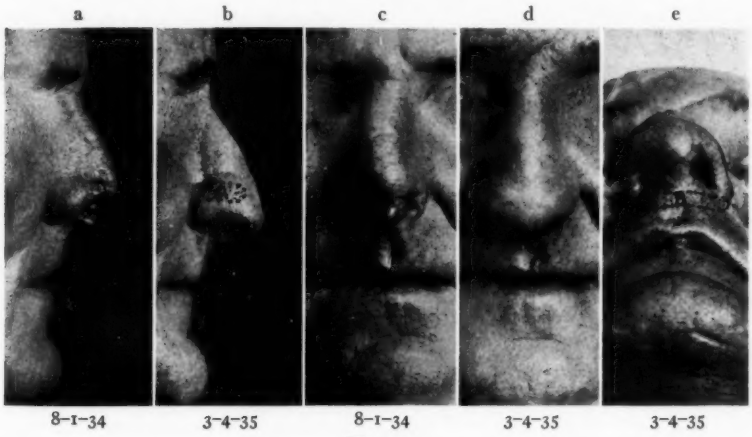

Fig. 15.

Fig. 15. a and c, One year after loss of tip and columella; narrowing of the vestibular floor and inspiratory collapse, with airways obstructed in a man, 40 years old. The repair was made in the standard way from a forehead flap, but it lacked intrastitial support. b, The inhalation collapse was controlled by undermining through incisions just within each vestibule, permitting insertion of thin strips of costal cartilage with perichondrium, facing mesially to cause a slight outward bulge. Through incision made at each labial alar junction and undermining, a narrow stiff strip of cartilage was inserted which restored the width of the vestibular floor, d and e.

The result was attained in six major and minor steps in 6 months. We have through the same approach put in a single piece of hooped cartilage, or a single piece for each side can be inserted through a short dorsal skin incision.

Supraclavicular flaps. To have the completely made nose of acceptably small size, especially upon a woman, the part of the flap that will form the alae and tip and be infolded for lining must be made very thin and at least 5 centimeters wide (Figs. 16 and 26). This is often not possible on a woman's forehead unless some scalp be included or taken as a bilateral double flap as in Figures 8 and 32. In older men, however, a receded hairline may become a blessing (Fig. 15) (5,a, 8,a).

Face, forehead, and small neck flaps can ordinarily be safely transferred after two preliminary steps (Fig. 12 was an exception): (1) Make circumferential or both lateral incisions, leaving but a small artery-carrying distal pedicle; undermine completely but avoid stripping the periosteum. (2) After 10 days or longer, but only after determining total absence of edema and the efficiency of the proximal blood supply by finger pressure on the distal pedicle, divide the latter and suture (Fig. 13).

With a well prepared forehead flap, it might be possible and expeditious to thin, infold, and completely attach the whole nose at one sitting. However, caution may dictate final thinning of the dorsal part only and temporary adjustment of the infolded part at the time the flap is first brought down. To insure a free vestibular airway without grossly increasing contour, secondary drastic thinning of the infolded part will ordinarily be required. The one-step thinning and affixing operation is most suitable in making a large nose of an older man where the blood supply is usually generous. For small noses the two-step application is almost mandatory.

A forehead flap with a temporal pedicle is poorly adapted to make a complete nose but can be used for dorsal covering, lining (Fig. 6) or patching the cheek (Fig. 23).

Infraclavicular flaps. Arm or body flaps should be raised in at least three stages, spaced at proper intervals. (1) Make but one lateral incision at a time, preferably full length *down to* the muscular fascia, and undermine in that plane more than one-half way across the proposed width; (2) 10 days to 3 weeks later, make the second lateral incision and complete the undermining; (3) after a similar interval or longer, cut half way or completely across

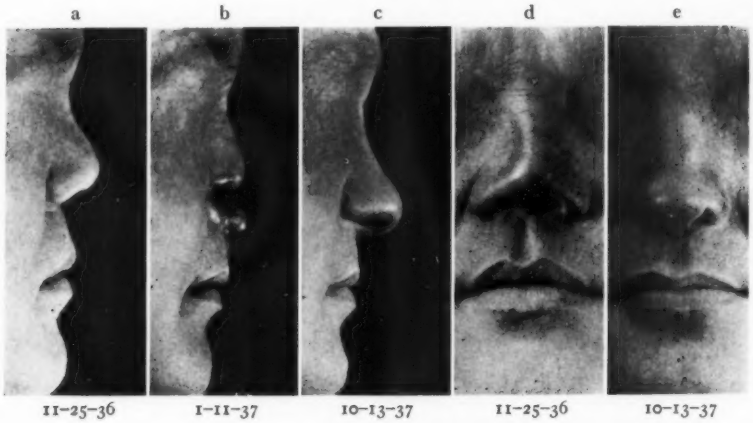

Fig. 16.

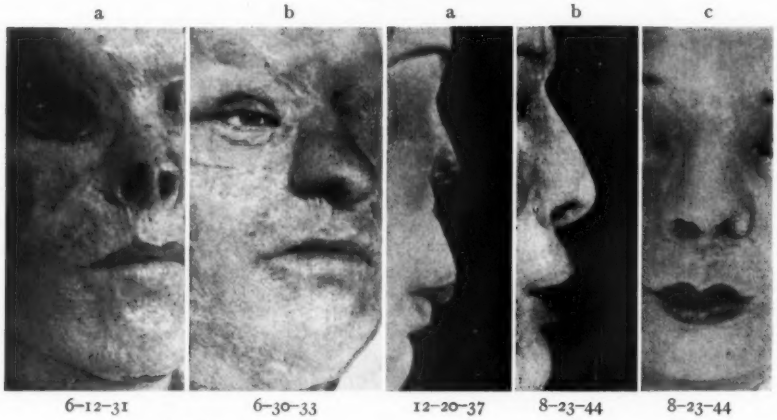

Fig. 17.

Fig. 18.

Fig. 16. A man, aged 33 years, had been injured in airplane crash. Following, he had unreduced nasal fracture. Cartilage and ivory implants had been introduced some weeks later. Nose was crumpled, columella retreated, and airway obstructed. a and d, Condition at our first examination. b, Under local anesthesia, the lower lateral cartilages, related mucous lining and vestibular floor scars were removed. The base of the columella was released and flaps of alar skin were implanted in the floor defect, thus advancing and lowering the upper part of the lip and the stub of columella. The lower border of the nasal covering was turned in and sutured to the lining to establish blood supply for a turn-down lining flap. c and e, The lip was shortened at its base to expose 4 millimeters of upper teeth. The dorsal covering and the vestibular foldings came from the forehead flap. Five major or minor steps were done in 8 months' time.

Fig. 17. Healed burn from gasoline explosion 2 years previously in a man, aged 37 years. Condition at our first examination is shown in a. An outlined upper neck, submental, left submaxillary flap, with base at right facial artery, for nasal repair, is partially shown by the submental lines in a. b, Completion of the work. The donor area of the neck was grafted. Incidentally, the scarred lower eyelid was released. This and the cheek were grafted. The covering of the right upper eyelid was made from two scarred forehead flaps, the conjunctiva having been sufficiently released. It required 9 operative steps spread over a period of 2 years to restore eyelids and nose.

Fig. 18. a, Condition after excision of upper lip, right cheek and nose for a greatly distorting lymphangioma, in a woman 24 years old. The soft tissue covering of the nasal bones was turned down to line and stiffen the central part of the nose. The nose was made from the arm with standard infoldings, but after this had healed in place the upper lip and the lower part of the nose were still retracted. To correct this a thicker piece of cartilage than that indicated in Figure 15, but with the same technique, was inserted with the result shown in b and c. At the same time the lip was shortened. b and c, Front and side views, were taken 7 years after repair was begun. This was done in 17 operative steps over a period of 8 years.

the distal pedicle, and if circulation warrants, the nasal covering part of the flap might be thinned and put up at this time. Never cut across the distal end until the flap has acquired an adequate circulation as proved by pressure test. Venous engorgement can cause gangrene in a pendant flap in spite of a generous blood supply.

At some step, the pedicle of a long arm or body flap might be partly or wholly "tubed," or the raw surface of both pedicle and bed can be covered with split skin grafts at this time, except the area to which the excess of pedicle will ultimately be returned. It is desirable in the original planning of a flap to allow for proximal lengthening should a partial loss occur at the distal end (Figs. 30 and 31).

For disproportionately long and narrow flaps on the trunk or neck, sectional tubing, interrupted by temporarily retained attachments to insure immediate blood supply, is a practical plan. These supply bases are later detached and tubed consecutively.

With a forehead flap where the pedicle comes from above, a few tacking sutures are sufficient to hold the transplant in place, but to compensate for the pedicle drag of a flap brought up from below, we use one row of buried very fine white silk sutures on either side, so placed as to give some up-crowding when tied, with a superficial row of fine sutures to insure accuracy of skin approximation. With a forehead flap, the buried sutures might be omitted. In either case, the superficial sutures are of black silk; the knots are not drawn sufficiently tight to leave marks and might be removed in 3 days. These are replaced by a one-layer patch of gauze affixed with flexible collodion. A heavy skin suture deeply placed at the lower end of the alar bulge may be used both to fix and shorten the vertical base of the bulge, which will tend ultimately to give a more natural lateral fullness to the ala.

The weight strain is further eased by a gauze strip fixed to the skin with *fresh* flexible collodion, lengthwise to the pedicle below, and above to the forehead. If into this traction line a section of elastic rubber band is introduced, the lift will be more uniform.

DIFFERENTIAL CHARACTERISTICS OF SUPRACLAVICULAR AND INFRACLAVICULAR FLAPS TABLE I. —

Flaps taken from face or neck	Flaps taken from trunk or limbs
Inapt	*Apt*
1. Hair-free donor areas may be embarrassingly limited especially on the forehead of a woman or the neck of a man.	1. Can be made almost any size. A. Body hair may be entirely negligible.
2. The scar of the donor area is always in sight, though this can be more or less camouflaged by skin graft and intradermal injection of color. Try to avoid a forehead defect on a woman.	2. Most donor sites are hidden by the clothing.
	3. Certain of the objectionable factors cited below in the inapt group do not hold true for flaps taken from the front of the wrist or border of the palm. Both are hairless and the latter is of good consistency and color and does not shrink. These latter can be particularly appropriate for certain small repairs such as restoration of a columella or an ala.
Apt	*Inapt*
1. The forehead flap is intrinsically the more desirable. It is relatively firm in substance with just sufficient elasticity to retain some spring, making it self-supporting. When folded to a sharply molded form it will shrink very little in healing or subsequently.	1. The tissues are relatively flabby and, with the exception noted above, unless supported are apt to shrink to an embarrassing extent.
2. The constituent layers are rather uniform in thickness and consistency which facilitates symmetry of molding.	2. Such flaps lack definite cleavage planes and closely adjacent areas may vary greatly in skin thickness and in the quality of the underlying tissue, all of which tend to negate both symmetry and sharpness of molding.
3. Total blood supply is relatively greater and more easily trained to a narrow pedicle; with ordinary precaution, hesitancy of healing or slough is rare but can happen.	3. The total blood supply will average less, its sources are more diffuse, a greater number of operative steps may be required to establish an efficient pedicle, or even one of doubtful value.
4. The basic blush color will persist or be early restored.	4. In flaps taken from below the clavicle the basic red is deficient or absent; however, this can be at least partially compensated by suitable injection of color, intradermally, but will yield no variation in blush.
5. Flaps taken from other nonhair-bearing parts of the face will have about the same qualities but of necessity will be much smaller.	5. The body hair may be negligible or so profuse as to require surgical depilation, control with chemical depilatory, scissors or razor.

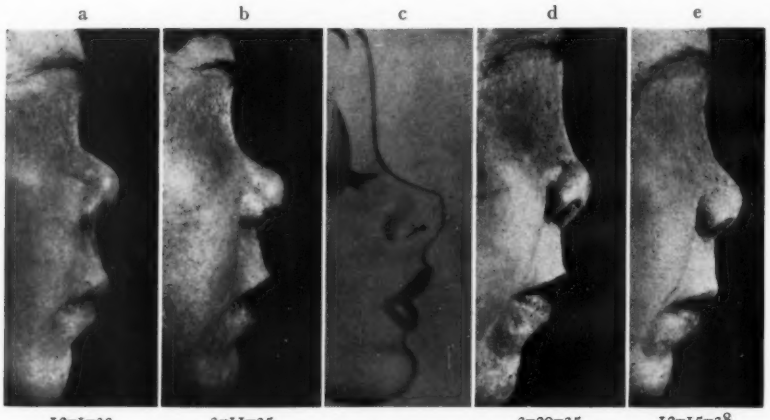

Fig. 19.

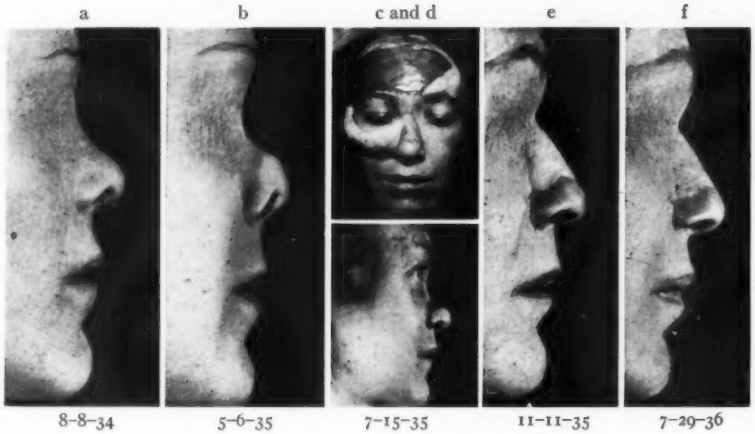

Fig. 20.

SERIES D. RESTORATION OF UPPER PART OF NOSE

The cases selected for this and the following series give even greater emphasis to the necessity for exact determination of the real extent of loss or distortion and the mode and possibilities of repair, before correction is instituted. Distortion of usable tissue should be entirely released before the flaps are put in place, yet the preparation of delayed flaps must usually precede the opening of the bed in which these rest. We have found a tape measure, a plaster cast of the condition, corrected with modeling clay, to be at least a partial solution to the what and the how of this dilemma (see Figs. 19 and 20 and ref. 5-b).

Forehead flaps should be cut very exact. With unrestrained subclavicular flaps, an allowance should be made for shrinkage. An incidental correction, as in the case of Figure 23, shows that it may be difficult to estimate how much addition to any eyelid or its foundation will be really needed. Here an overcorrection can be dealt with by simple excision, while secondary additions are apt to be as complicated as the original implantation (Fig. 23).

Fig. 19. Saddlenose; loss of vestibular lining and columella in a woman aged 28 years. a, Condition on first examination with scarred lining and a threadlike columella. b, Immediate result of wrist flap implantation used first as vestibular lining after undermining up to the glabella and pulling down the nose. At a second step, the pedicle of the wrist flap was used to make the columella. c, Commercial poster exaggeration of type shown in b, which is an acceptable one for certain faces. d, The patient was satisfied and we also should have been, but thought further improvements would come by inserting a strip of cartilage into the dorsum. This proved to be a minor operation but a major blunder (compare b with d). e, The result obtained after eight subsequent steps, including some actual lengthening of the dorsum. Fourteen operative steps, major or minor, were required over a period of almost 5 years.

The first blunder was not resting with what was satisfactory to the patient. The second was that bringing forward the bridge of that tilted nose upset facial balance. The third was the compromise attempt to steal narrow covering

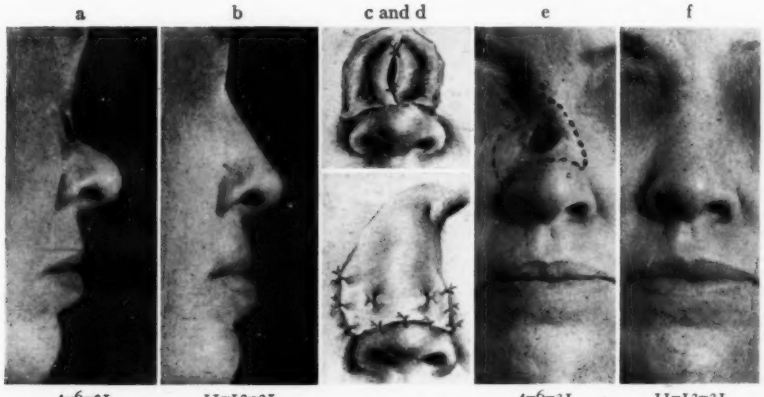

Fig. 21.

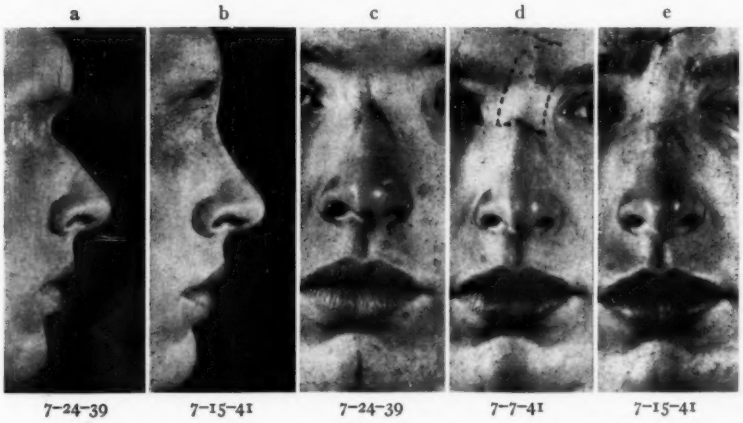

Fig. 22.

and lining flaps from just above the brows in the hope of avoiding a grafted forehead. The flaps obtained were too narrow to give proper length to the dorsum, and undermining of the forehead tissues to above the hairline failed to prevent drawing up of the brows. This latter gives an apparent overlengthening to the dorsum of a still turned-up nose; a grievous error.

Fig. 20. a, Saddlenose, the result of an unreduced fracture 12 months previously, in a woman 26 years old. b, Attempted correction by intranasal chisel-mobilization and wire fixation at first gave promise of being acceptable, but with subsidence of the postoperative swelling, the lack of bony fixation, due to too early removal of wire, permitted a progressive distortion, as shown when she returned 6 months later. Adequate fixation for a sufficient period should give union where there is any bony contact. The plan we have used is an interstitial wire loop embracing the nasal spine above and fixed to the maxillary incisors below. This can be retained for 3 months if necessary. c and d, As a secondary attempt, the vestibular portion was completely severed from the bridge by transverse incision, see d. Subsequently, the natural dorsal covering was turned in to line the defect and the whole was covered with a previously prepared forehead flap that had a temporal pedicle, shown in d. e, As with our first attempt, the immediate result appeared to be quite satisfactory, but 7 months later the lower part had slipped backward, as seen in a similar case, Figure 11, b. f, Final result was further helped by implantation of costal cartilage into both the dorsum and columella. A total of 13 operations with 3 failures, due largely to lack of sustained postoperative fixation of the mobilized mass, was required over a period of 2 years.

Fig. 21. a and e, Healed result of extensive cauterization done 2½ years previously, on a woman, aged 39 years. The dashed marks on e indicate the source of the lining flaps. c, The flap tissues surrounding the defect, outlined as in e, were undermined, turned in to give a ridged lining to the previously depressed dorsum. The surrounding tissues were further undermined to widen the bed for the covering flap. d, The forehead flap was put in place with the dorsal ridge maintained by temporary mattress suture. b and f, Result shown 6 months after completion of the correction (8, c). In this case 3 operative steps were completed in 7 months' time.

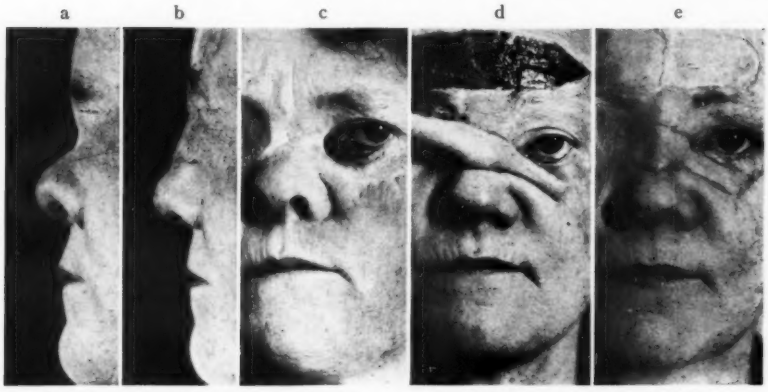

Fig. 23.

Small patches of adhesive plaster prevent the cutting in of this necessarily tight mattress suture. Gauze wads used for this purpose might cause necrosis.

Fig. 22. A man, 19 years old; subglabellar fracture-displacement from airplane crash. There were impingement on the nasolacrimal grooves, great displacement of the left inner canthus and suppuration of the lacrimal sac on this side. a, and c, Condition at our first examination 10 months after injury. e, Result obtained by removing displaced bone and suppurating sac, repositioning of canthus fixed by transnasal 40 day gut suture. Overcorrection will subside after gut loop absorbs. d, The superimposed diagrams indicate the repair flap and also the position of use. The displacement of the right inner canthus was partially corrected at this time by buried suture. b and e, Final result. This required but 2 operative steps with 2 years intervening.

The right inner canthus could have been brought farther mesially. The forehead defect was overcome mostly by wide undermining and suture. The remaining uptilt of the inner end of the right brow could be further corrected by a "Z" flap operation, but the patient wished to avoid this additional step. We have seen several such injuries due to rifle wounds in soldiers. If both eyes were intact, the man was grateful for the correction, but where one eye had been destroyed, he was apt to complain of the resulting narrowed visual range of the remaining eye.

Fig. 23. Ulcerations of face, mouth and pharynx, starting 20 years previously, in a woman aged 43 years. a and c, Saddlenose, perforation at inner canthus, and loss from the upper part of the cheek, causing a distortion of the lid, extending to the outer canthus. d, A too narrow and too short forehead flap with a right temporal pedicle was cut. The distal end was split. The cheek scar had been opened as far as indicated in d, which was not far enough. Nasal lining was obtained from the lower part of this flap. The insufficient upper part but partially filled the defect. Later the pedicle was cut across and returned to the forehead, while the mesial portion filled in the defect resulting from the letting down of the nose. At this time the remaining raw area was grafted. The tarsus is still not in full contact with the globe. b and e, Final adjustments of the flap. The transverse ridge on the nasal part of the flap, 1 week after final adjustment, is partly swelling and partly an allowance for spontaneous dropping of the nasal tip, b. In e, the residual ectropion, still so evident in d, has been partially corrected by liberation and insertion of a full thickness graft from behind the ear. This required 7 operative steps, major or minor, completed in a period of 5 months.

The primary fault here was making the forehead flap too short and too narrow. A longer flap would have permitted opening of the full length of the cheek scar, shown in c, and greater width would have brought the tarsal border well up to its proper position, thus avoiding the several subsequent steps. Further, the supplementary skin graft is also too small; one wider and longer could have compensated for much of both faults.

The use of the inframandibular or infraclavicular flap gives no choice but for at least a two-step operation for affixing the flap attachment and final molding. Only the dorsal attachment with corresponding thinning can be done at the time of transfer. The special thinning for the columella and alar infolding is, of necessity, postponed until after establishment of the new blood supply and the division of the pedicle (Fig. 31). The vestibule is lined and the columella formed by infolding of the extra length of the nasal flap already provided for this purpose (Figs. 1,c and 18). In a nose intact above the vestibule any needed lining can usually be derived from the original dorsal covering but in a total restoration, an extra flap may be needed (8,a). It may be desirable, but more frequently not practical, to make the columellar infolding wide enough from above down to admit later a cartilage transplant to support the rounded tip so common to total noses thus made (Figs. 20, f, 26).

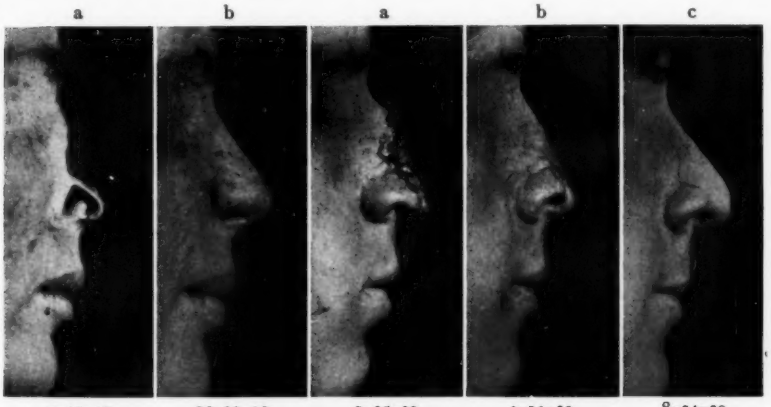

Fig. 24.

Fig. 25.

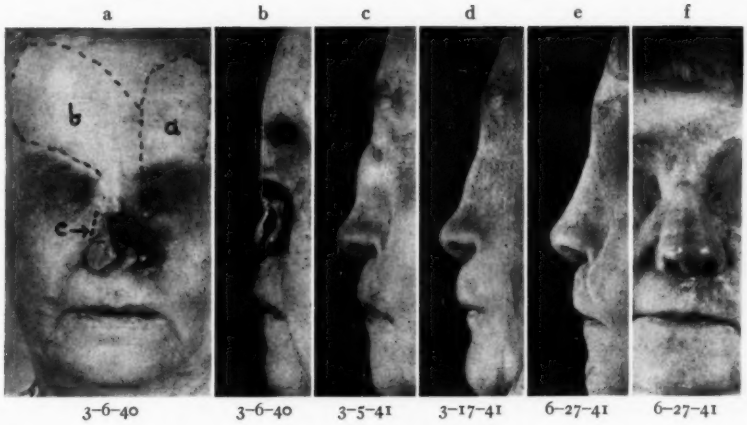

Fig. 26.

SERIES E. SUBTOTAL RESTORATION OF THE NOSE

Usually a sufficient amount of the nasal framework remains. In certain cases, restoration of the dorsal line can be more easily attained by bone cutting than by cartilage implantation, but both might be used in a given case (Fig. 26).

In all restorations, whether great or small, integrity of the lining is as important as the covering. Restorations after total loss are done on the same lines but an extra nasal flap or graft may be required for lining of floor, dorsum, or both (5c and 8a).

Fig. 24. a, Subtotal destruction of the nose by cancer paste, in a woman 35 years old. b, Result 12 days after repair with forehead flap for covering. The lining came from turning in the remaining dorsal tissue. Repair completed in four operative steps over a period of 3 months. Here a forehead flap gave a good dorsal line without other support.

Fig. 25. Auto accident caused subtotal loss of bone, cartilage, and covering in this 17 year old girl. a, A lesser loss than in Figure 24. Note the now too prominent remaining part of the bony bridge. b, Result of chiseling off the hump and approximating the bones before transfer of the repair flap. c, Repair with an arm flap. This gives a rounded tip, characteristic of a repair with almost any subclavicular flap (Fig. 17) as distinguished from a forehead flap repair (Figs. 24 and 26). This required 8 operative steps, major or minor, in 6 months.

Fig. 26. Healed subtotal cautery destruction of the external nose, left antral wall, cheek, and lower eyelid in a woman, 69 years old. a and b, Repair made with flaps, *a*, *b* and *c*. At intervals, the left forehead flap was sutured into the freshened cheek defect with the mesial edge being turned in also to supplement the nasal lining of that side. At the primary raising of flap *c*, the lateral incision was made to the bone for right cheek fixation. c, In molding the nose, flap *c* was rotated to piece out the lining of the left side; *b* furnished dorsal covering and vestibular infoldings. With the settling of this soft tissue nose, there was sinking of the lower part of the dorsal line. In the case in

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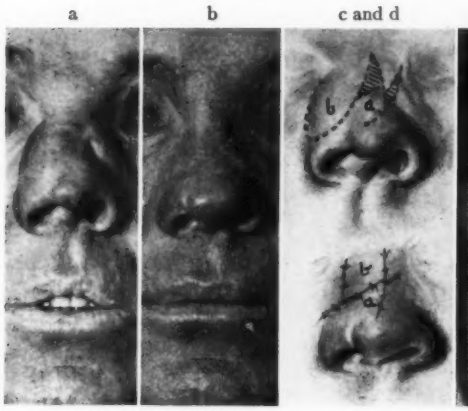


Fig. 27.

Fig. 28.

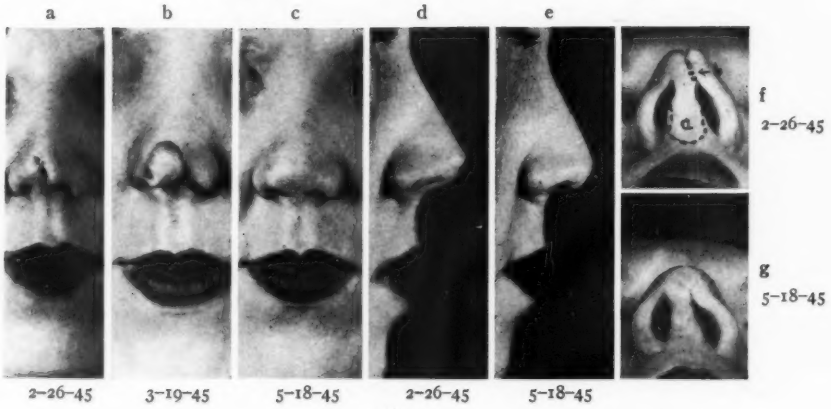


Fig. 29.

Figure 25, this prominence had been removed before the covering flap was brought down. Here the upper part of the flap was turned down and the bony prominence trimmed, but preserving the mucous lining without approximating the nasal bones, with the result shown in d. e and f, Later cartilage implantation into both the dorsum and columella further supplemented the lacking framework.

SERIES F. REPAIR FLAPS DERIVED FROM THE NASAL TISSUES

Three cases are cited to illustrate instances of this sort.

Fig. 27. a, Distortion of the nasal framework from a childhood injury in a man 36 years old. b, Straightening and lengthening of the nose were attained by switching the soft tissue flap *a* and the osteoplastic flap, *b*, to the midline, as shown in c, undermining and suturing the bordering soft tissue shown in d. Swelling in the nose is still present in b. This was done in one operative step.

Fig. 28. History of full thickness radium destruction done 10 years previously in this woman, 55 years old. a, Defect; dotted line indicates trapdoor flap that was turned in for lining. b, Raw surface of nose and lining flap covered with a previously prepared forehead flap.

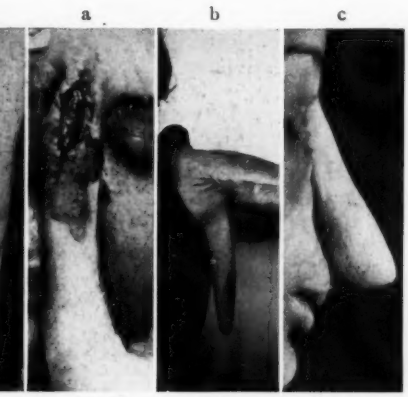
A simpler plan might have been one using a free postaural skin graft in place of the covering flap.

Fig. 29. a, d, and f, Result of destructive abscess in childhood with complete epithelium-lined perforation into the left vestibule, in a woman 28 years old. In f, the dotted outline, *a*, indicates the flap raised from the wide proximal part of the columella and adjacent lip, with anterior part of the former used for pedicle. *b*, Indicates division of persisting skin bridge. b, The flap, *a*, switched into the opened and freshened defect. c, e, and g, Right half of the implant remains in place. Pedicle and left portion are turned down and implanted into the proper position. Note the narrowing of the base of the columella in g.

Transfer of flaps. No flap should be transplanted while (1) any patent edema or induration persists, (2) the patient is in a poor general condition, or (3) there is skin infection,

12–12–27 1–18–28 3–23–28

Fig. 30.



1–1–38 3–27–39 6–30–39

Fig. 31.

SERIES G. ARM FLAPS

Given a sufficiently bare area, a forehead flap may be cut to the desired size with little or no allowance for shrinkage (Fig. 1, a), but for the arm or body flap (Fig. 1, b), there is not only a natural tendency to shrink, for which some allowance should be made, but the weight of the pendant pedicle tends to elongate the latter at the expense of width, so that what at first appeared to be ample may have to be supplemented or the whole transplant discarded. It is for this reason that we cut an arm flap not only wider than apparently needed but make the pedicle even wider than the lateral extensions for the alae (Fig. 1, b). The extra weight also demands more meticulous suture or an overlay of the borders of the flap to be adjusted later. Supplementary elastic support of the looped pedicle by rubber band traction, anchored to collodion-affixed gauze patches, will greatly alleviate weight strain at the suture line.

For comparison of adaptability, see Table I and Figures 30 and 31.

Fig. 30. Sloughing arm flaps. Reactions still four-plus after four previous courses of treatment. Nose operation was uneventful after usable flap was secured. (See discussion of case in Figure 10)

a, A diffuse slough in an inner arm flap after making both lateral incisions and complete undermining in one step. The flap was abandoned on account of diffuseness of the slough. In several of our earlier cases, with success attributed to "fool's and beginner's luck," we raised large arm flaps in two steps, but a good routine is a minimum of three steps.

b, Sharply outlined slough of a flap from the outer surface of the same arm after incising and raising the flap in two steps, but still without dividing the lower pedicle. Because the slough was sharply outlined and limited to a distal fourth, the flap was nursed along until it had completely healed without any suggestion of change or impaired circulation. c, Spontaneous drawing in and healing of the damaged area, when the flap was successfully used with no hesitation of the circulation. Subsequent observations have forced the conclusion that in this and other losses, the fault was with the plan and not the tissues. This is also emphasized in the case of Figure 31 in which there was no blood dyscrasia.

Fig. 31. Partial raising at two sittings. At the time of application, circulation in the flap appeared adequate, but it sloughed following implantation, see a. b, Flap was taken down and allowed to heal with good circulation throughout the remnant. Fifteen months later with some secondary lengthening at the base, this flap was again put up, b, with no hesitation. The skin graft repair of the arm, shown in b, was done while awaiting recovery of the sloughed flap. In c, the transverse division of the healed-in-place flap was at the level of the mouth slit. Higher than that is not safe, as shown by the shortening which occurred after releasing the weight of the pedicle. (For discussion of case see Fig. 18).

but a proper delay will likely eliminate the difficulty.[1] No flap should be transplanted, the circulation of which had hesitated sufficiently to cause blebs, deep discoloration or diffuse gangrene. Such a flap would, most likely, not survive both thinning and transfer (Fig. 30,a). We would consider worth while the attempt to use a flap that had suffered a sharply outlined distal loss from a frank gangrene provided the flap was still sufficiently long or could be lengthened (Fig. 30,b). After a second hesitation, the flap should not be used. Forced abandonment of a flap at any stage is an embarrassment to the surgeon and more so to the patient. However, loss of a transplanted flap is a catastrophe (Fig. 31).

Correction of deformities resulting from trauma or disease. The first move in the repair of the donor area is the return and adjustment of the unused pedicle. After this has been transferred and the desired surgical correction made, the remaining deficiency at the donor

[1] A moderate activity of chronic acne that frequently follows a train trip or other incidental irregularity can usually be quieted and the patient made operable by one exposure to radiation of proper length and intensity.

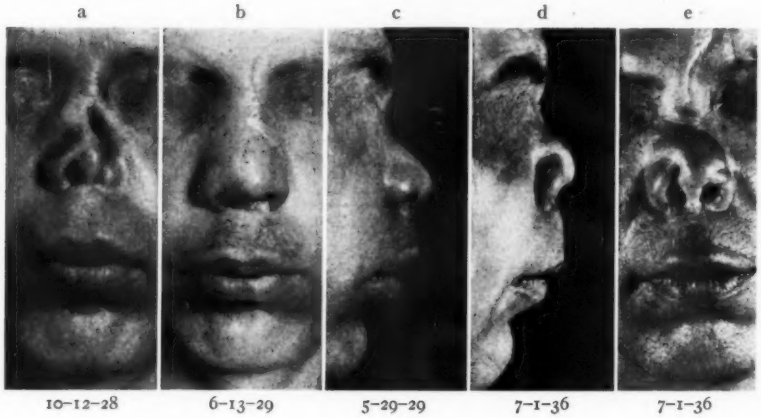


Fig. 32.

Fig. 32. This case emphasizes the need of continual postoperative caution in any congenital or acquired infection.

Nasal and throat ulcerations for 2 years previous to recognition of the cause. Recent treatment of this 30 year old man had brought his blood reaction down from four to two-plus. a, At our examination he had scarring of the pharynx and palate, internal nasal destruction and some full thickness loss. Medication was discontinued for a period before operative correction was undertaken, as is our custom. We used two forehead flaps, one for lining and one for covering (Fig. 8). After these had healed in place, he was sent home for rest and further intensive treatment. Later we inserted a cartilage graft into the dorsum, with the result shown in b and c. The length of time treatment was continued after cartilage insertion is uncertain, but he returned 7 years later with the wreckage which is shown in d and e.

site should be eliminated. Granulating or rough scar must be camouflaged or hidden. The borders of small defects might be undermined and approximated, while others must be grafted. It is hardly practical to use a full thickness graft at the time of flap transfer. A split graft might be less conspicuous if drawn tight over a 3 or 4-week old bed of smoothly trimmed granulations as is our common practice on the forehead. On the trunk, residual disfigurements can be hidden by clothing, which is also true of a man's arm. In a woman, an arm flap should be taken preferably from the inner surface; she can quickly acquire the habit of holding the damaged area close to the chest which makes a smoothly grafted area quite unnoticeable.

It is the exposed donor area of the forehead or arm and repair tissue that does not blend with the surrounding color that chiefly attracts attention. It is very seldom that an infraclavicular graft or flap will have any of the natural facial blush after transfer, but it may become more tanned than natural. No matter how perfect the technique, a marked color discrepancy will vitiate an otherwise quite acceptable result. Most women but few men will use cosmetics or surface stains. The natural red comes from the depths of the skin and surface applications are but easily detected substitutes that lack the true blush coloring. To match free skin grafts and pedicle flaps more nearly with the surrounding skin, pigments can be instilled into the derma of transplanted skin with fine needle points (9).

On the forehead, the original split graft is later discarded for an evenly fitted full thickness graft which is allowed to season before intradermal color is injected. The natural changing face-tinges are live and these cannot be duplicated even by color instillation, but this method is still our best substitute. The tenacity with which the transplant clings to the color characteristics of its source suggests the possibility of some intrinsic local control. For example, grafts and detached transplants taken from below the clavicle will, in most instances, eventually lose all vestige of red, while flaps from cheeks or forehead, also postaural grafts, will retain or regain their natural blush shade.

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OBSERVATIONS ON THE TREATMENT OF ADENOCARCINOMA OF THE UTERUS

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IN the past 3 years, 10 women with adenocarcinoma of the uterus, comprising 0.5 per cent of the patients on the gynecologic service, have been treated at Walter Reed General Hospital. These cases are presented without 5 year follow-up for two reasons: residual carcinoma was found in 6 of the 7 uteri which had received enormous doses of radium by means of the hysterostat designed by one of us (M.F.); and the presence of ovarian metastasis in 3 patients emphasizes the necessity for oophorectomy as part of the treatment.

Recent reports have suggested that panhysterectomy with bilateral salpingo-oophorectomy should result in a 5 year arrest of 60 to 65 per cent of operable lesions (4, 11). The impression that the 5 year survival rate may be increased to 70 or 80 per cent by the use of preoperative radium followed by hysterectomy has been growing during the last 10 years. The majority of recent authors have advocated this combined method of treatment. Because small doses of radium in the order of 1,500 to 2,500 milligram hours have relatively little effect on adenocarcinoma of the uterus, conclusions drawn by authors who employed these small doses are of questionable value. The few reported cases treated with 4,000 or more milligram hours of radium are inadequate for a correct statistical evaluation of the combined method of treatment.

Corscaden (1944) reported 25 cases in which patients were treated with radium and hysterectomy in which the 5 year survival rate was 72 per cent. He recommended 3,000 to 4,500 milligram hours if given in one massive dose. Sheffey (1943) reported 30 cases in which patients were treated with combined therapy in which there was 38.4 per cent survival after 5 years. Only 9 of the 30 patients received doses of 4,000 to 5,000 milligram hours. In his cases of patients treated by surgery alone, the 5 year survival rate was 18.1 per cent.

Ward (1942) reported 37 cases in which combined treatment had been used with 64.9 per cent 5 year survival, as compared with 63 per cent in 27 cases in which surgery alone was used. The radium dose varied from 2,400 to 4,000 milligram hours, followed by postoperative x-ray therapy.

Heyman (8) in Sweden (1937) reported 5 year arrest of 78.5 per cent of 65 cases in which treatment consisted of hysterectomy followed by radium and x-ray therapy. In 1941 (9) he reported a series of 402 including inoperable cases in which patients were treated with radiation alone, with a 5 year survival rate of 40 per cent. Included in this group were 156 clinically operable cases in which patients were treated only by radiation and in which the 5 year survival rate was 48.7 per cent. He did not employ the combined treatment of radium followed by hysterectomy except in one subgroup of patients, who were operated on after radium therapy had failed; in this group the survival rate was 46 per cent. The usual radium dose was 3,000 milligram hours delivered in two applications of 1,500 milligram hours at an interval of 3 weeks.

Brindley (1941) reported 24 cases with 79 per cent 5 year survival. He used the combined treatment. The radium dose varied from 800 to 4,800 milligram hours, averaging 2,600 milligram hours.

Miller (1940) reported 34 cases in which treatment consisted of radiation followed by surgery. The 5 year survival rate was 70.5 per cent. Although he recommended pre-

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operative x-ray therapy only, the exact number of patients so treated and the dose were not mentioned.

Morton (1939) reported 18 cases in which the combined treatment produced a 66 per cent 5 year cure. Thirteen additional cases in which surgery alone was used had a 69 per cent 5 year survival rate. The dose of preoperative radium was not specified.

Healy and Brown (1939) reported 28 cases in which 3,000 to 4,000 milligram hours of radium was administered preceding hysterectomy. The 5 year survival rate was 79 per cent.

Arneson (1, 1936) treated 10 cases with radium, followed by hysterectomy, to obtain a 5 year survival rate of 90 per cent. The dose of radium varied from 1,600 to 4,000 milligram hours, 6 patients receiving more than 3,000 milligram hours.

These published reports of a relatively small number of cases have been influential in determining the present trend toward combined therapy. The statistics in themselves are not conclusive. The recognized abilities of the authors, however, demand that their opinions be given careful consideration. Presumably, there are favorable clinical impressions of individual patients salvaged by the combined method, which are not entirely reflected in the statistics.

In 1934, Sampson warned that a straight radium tandem in the uterine cavity failed to irradiate the uterus homogeneously and that carcinoma localized in the cornu might be unaffected. In spite of his admonition the straight tandem continues to be widely used. Other methods of using radium in the uterus include multiple packing of loose capsules with strings attached, or incorporation of capsules in a gauze pack (2). The capsules have been attached to wires (4, 5) in an attempt to "fan out" the radium. Several other devices have been designed (10, 16, 18).

RADIUM TECHNIQUE

The radium applicator, which is called hysterostat, was designed to achieve a more equable distribution of radiant energy to all parts of the uterus. Its construction was based on the following features:

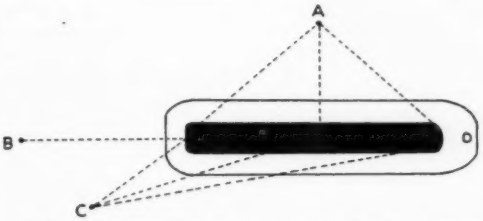

Fig. 1. Diagram illustrating intensity of radium energy distribution around platinum capsule. The greatest intensity is found along the side, point *A*. The weakest intensity of radiation is located at point *C*, which lies obliquely off the end of the capsule. A pencil beam of weak radiation comes directly off the end of capsule to point *B* (see Fig. 2).

1. Study of the distribution of radiation energy around a radium capsule with a wall thickness (filter) of 1 or 1.5 millimeter of platinum reveals certain data of utmost importance to successful use of radium in the uterus.

a. The greatest intensity of radiation is found along the side of a radium capsule (point *A*, Fig. 1) due to a filtration factor and a distance factor. Most of the rays emanating from all points along the radium source travel obliquely through the metal wall of the capsule to reach point *A*. The longer path through the wall of the capsule, which the oblique rays must traverse, subjects them to increased filtration in the metal wall. However, this increased filtration is at a minimum for point *A*, as compared with all other points equidistant from the outer wall of the capsule (point *C*, for example). In addition, the average of the distances, which the rays traverse from each point along the radium source to reach point *A* along the side of the radium capsule, is shorter than for point *C* or any other point equidistant from the wall of the capsule.

b. The weakest intensity of radiation from a linear radium capsule is located at a point obliquely off the end of the capsule (*C*, Fig. 1); because the average distance which the rays, from each point along the radium source, travel is longer than for point *A*. Furthermore, many of the rays traveling obliquely through the wall of the capsule to reach point *C* must traverse eight or more times the stated thickness of the metal wall before emerging from the capsule. Thus the high filtration considerably decreases the intensity of the total radiation reaching point *C*.

c. Radiation coming directly off the end of a linear radium capsule to point *B* in Figure 1, is filtered only with the minimum stated filter of 1 or 1.5 millimeters of platinum. This advantage is neutralized by the fact that the average distance which the rays traverse, from each part of the radium source, is the longest of all the average distances. As a result, a narrow pencil of increased

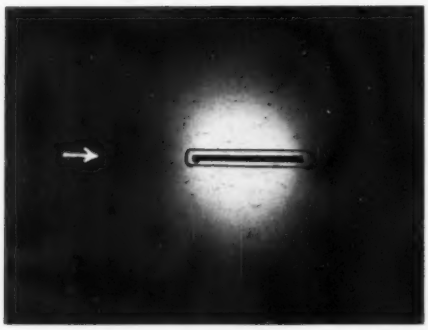

Fig. 2. Actual picture of radiation intensity distribution made by placing a radium capsule against an unexposed film suspended in air. The radium element source is 2 centimeters long, and the wall of the capsule is 1.5 millimeters of platinum. Note the great intensity of radiation along the side of the radium capsule, and the equally striking weakness of the radiation coming off the end of the capsule, with the exception of a narrow pencil beam (arrow) in the long axis.

radiation intensity comes off the end of the capsule (see arrow, Fig. 2).

d. The great intensity of radiation along the side of the radium capsule, and the equally striking weakness of the radiation coming off the end of the capsule are illustrated in Figure 2. These facts are significant when the tissue to be irradiated comes in direct contact with the radium sources, in the treatment of corpus carcinoma.

2. When several capsules are placed perpendicular to a surface, the intensity of radiation reaching that surface will be relatively small. In Figure 3, although 2 capsules are pointed at the cornu, it receives less radiation than those parts of the uterine wall in direct contact with the sides of the capsules.

3. For effective radiation of the fundus of the uterus, one or more radium capsules must lie flat against it. Several tandems or individual capsules pointing at the fundus perpendicularly will not provide comparably effective radiation. The crosspiece of the hysterostat permits proper placement of radium against the fundus (Figs. 4 and 5) and can be adjusted to provide contact with a concave fundus (Fig. 12).

4. Studies of energy distribution around radium sources, according to the Paterson-Parker "dosage system for gamma ray therapy" (14), indicate that radium sources should be placed peripherally around an area which is

Fig. 3. Self-exposed photograph made with hysterostat containing 6 radium capsules, as in Figure 5b. Hypothetical uterine canal is 7 centimeters long. Although two capsules are pointed at each cornu, the weakness of radiation intensity in the cornu is readily apparent. The fundal myometrium is effectively irradiated by the crosspiece. The midpoint of the triangle is irradiated by crossfiring from all the capsules, so that additional radium seems unnecessary.

to be homogeneously irradiated, within certain spatial limitations. The addition of multiple sources within the center of this area (packing a uterine cavity with multiple radium capsules) serves to increase the intensity of radiation within the center of a cavity, where it is already high (Fig. 3).

5. The hysterostat is constructed of multiple sections which can be screwed together in the operating room, after the contour of the uterus has been defined, so as to produce a roughly triangular distribution of radium sources within the uterine cavity. Each section is the length of a single radium capsule. Sections in two angulations (150° and 165°) are provided so that a uterine cavity of almost any size or irregular configuration can be fitted (Figs. 5a, b, c). The crosspiece (Figs. 4 and 5) is so arranged that it can occupy four different predetermined angles in relation to

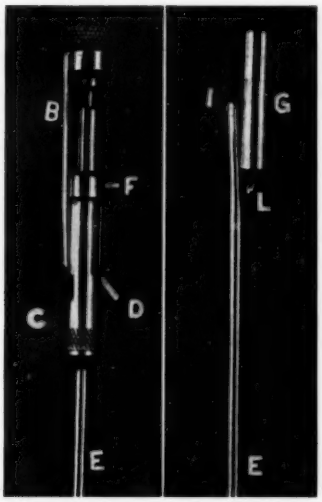

Fig. 4. The crosspiece. The handle end is on the left, the radium end on the right. The flange, *B*, is attached to knob only, and slides into the limiting slots, *D*, in the revolving sleeve, *C*. The flange must be pulled below the fixed guard, *F*, before the sleeve can be rotated. *E*, Tubular stem through which runs the central wire.

At the radium end of the crosspiece is the shell, *G*, which can be unscrewed and a radium capsule inserted. This can be made any desired length by adding extra straight or angular pieces. The shell is attached by a hinged joint, *I*, to the end of the tubular stem, *E*. The central wire emerging from the tubular stem is attached to one end of the shell by means of an axle joint *L*.

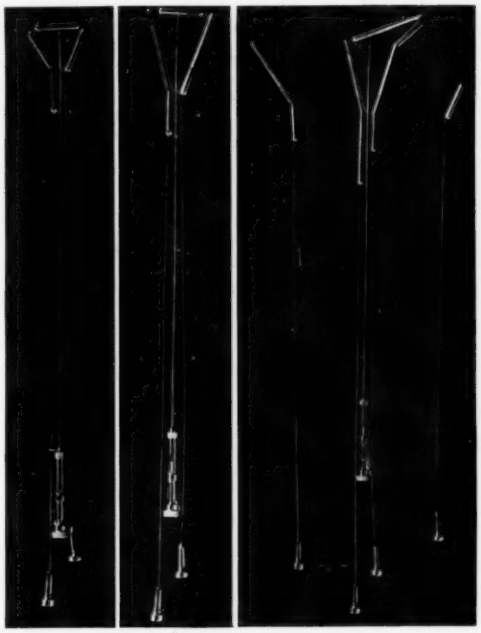

Fig. 5. Crosspiece and lateral tandems arranged in 3 different hypothetical distributions. a, Arrangement of 4 capsules in a uterine cavity 5 centimeters long. One lateral tandem contains a 150 degree angle section. The other lateral tandem is angulated by bending the flat stem. b, Arrangement of 6 capsules in a uterine cavity 7 centimeters long. This has been accomplished by inserting an extra section into each lateral tandem. c, Arrangement for a large, irregular uterine cavity. The additional 2 lateral tandems are available in case a large uterine cavity can accommodate them. Note that each arrangement of the applicators provides one radium capsule in the cervical canal.

the supporting stem. Four side-pieces are provided, but only two of them are needed except in unusually large uteri.

The sheaths which contain the radium capsules are constructed of monel metal tubing with a wall thickness of 0.4 millimeter which provides an ideal secondary filter. These sheaths can be constructed to contain radium capsules of different sizes. We have employed two sizes, 4 by 23 millimeters and 6 by 18 millimeters.

6. The radium dose which we employ has been arrived at by empirical means. Calculation of the distribution of the radium energy to various parts of the uterus in units of gamma roentgens has not yet proved to be of practical value in ascertaining the desired radium exposure of a particular uterus under treatment.

The individual capsules contain 10 or 15 milligrams radium, with a primary filter of 1 or 1.5 millimeters platinum and a secondary filter of 0.4 millimeter of steel. A dose of 1,000 milligram hours per capsule is given when the uterus is normal in size. A small uterus with a cavity 5 centimeters long, holding four capsules, will receive a total dose of 4,000 milligram hours, given in one treatment. If the uterus is larger and contains more radium capsules, the individual dose per capsule is from 700 to 1,000 milligram hours. The total doses in this series ranged from 6,000 milligram hours to 12,480 milligram hours.

Generally, when the uterus is larger than normal and the total dose is to exceed 5,000 milligram hours, radium is given in two treatments at an interval of 7 to 10 days. The

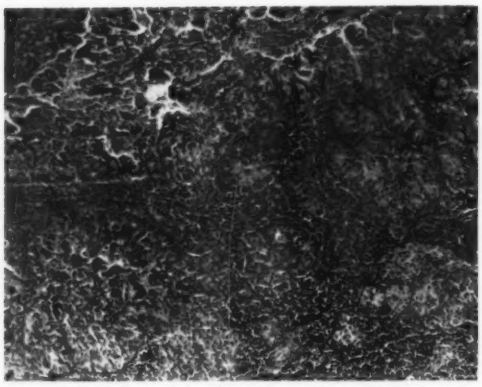

Fig. 6. Case 1. Biopsy before x-ray therapy. This growth is classified as a moderately undifferentiated adenocarcinoma originating in the endocervical glands. The tendency to form alveolar structures is clearly shown. ×63.

uterine canal usually shrinks, and its shape changes after the first treatment, so that the radium must be rearranged for the second treatment.

This technique had been employed in 28 cases by one of us (M.F.) in civilian life, prior to 1942. The radium exposures in half of these ranged from 6,000 to 10,230 milligram hours. These cases will be the subject of a future publication.

Several other devices have been designed for the purpose of obtaining diffuse distribution of radium energy throughout the uterus. Schmitz, using a Y-shaped applicator, administered doses up to 6,000 milligram hours. Kaplan, employing a "ring" applicator, administered doses ranging from 6,000 to 7,910 milligram hours.

CASE REPORTS

CASE 1. Moderately undifferentiated adenocarcinoma of the cervix, slightly advanced.

A moderately well nourished white female, aged 39 years, was admitted to the hospital September 8, 1944, complaining of intermenstrual bleeding for 3 months. She had one child aged 17 and had had one miscarriage 2 years ago. Menses were regular every 28 days, lasted 7 days, with moderate flow and no pain. Six weeks before admission, the patient noted a mass protruding from the vaginal orifice, which disappeared when she lay down.

On examination, the abdomen was flat and soft, with no masses or tenderness. The vagina was normal. Protruding from the cervix was a hard, rounded mass, 5 centimeters in diameter with a red granular surface which bled easily. The uterus was of the usual size, anterior, and free. Ovaries were normal. There was no induration in the broad ligaments.

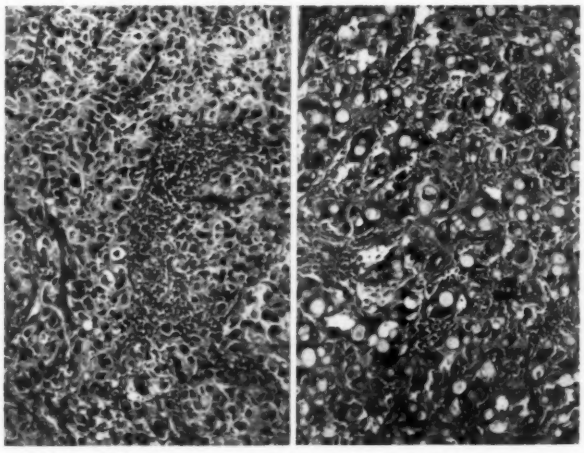

Fig. 7. Left, Case 1. Biopsy 18 days after x-ray treatment started (3 days after completion of tumor dose of 3,030 r delivered over a period of 15 days). There are slight to moderate radiation effects, predominately nuclear hyperchromatism and to a less extent cytoplasmic swelling. ×70.

Fig. 8. Case 1. Another area of section shown in Figure 7. Here the radiation effects are much more striking. ×70.

Fig. 9. Case 1. Entire uterine cavity showing granulating endocervical surface at site of tumor. The upper portion of the corpus appears relatively normal.

Biopsy of the endocervical tumor showed moderately undifferentiated adenocarcinoma (Fig. 6). Supervoltage x-ray therapy was given with rays activated at 1,000,000 volts over a period of 15 days. The skin dose ranged from 1,000 r to 1,500 r to each of five skin portals. The tissue dose delivered to the tumor in the cervix was 3,030 r.

Three days later (18th day after initiation of treatment) the cervical tumor had shrunk about 20 per cent, and measured 4 centimeters in diameter. The uterine cavity was curetted, and the tissue obtained was benign proliferative endometrium. The cervical tumor was excised with endothermy. A radium tandem, composed of 3 platinum capsules totalling 60 milligrams of radium, was introduced into the uterine cavity; and three corks, each of 15 milligrams radium, were placed in the vagina about the cervix. A total dose of 8,000 milligram hours was given.

Microscopic examination of the cervical tumor (Figs. 7 and 8) revealed, in response to 3,030 r, extensive destruction of tumor cells. Those remaining showed moderate to marked changes, predominantly nuclear alterations, and to a lesser degree, swelling and vacuolation of the cytoplasm.

Sixty-five days after radium, abdominal panhysterectomy and bilateral salpingo-oophorectomy were performed, the Richardson technique being used. The peritoneum and intestines were normal; no enlarged lymph nodes or induration were present. The uterus was small and atrophic (Fig. 9) as were the tubes and ovaries. There were no adhesions. The postoperative course was entirely uneventful, and the patient was discharged on the 18th day.

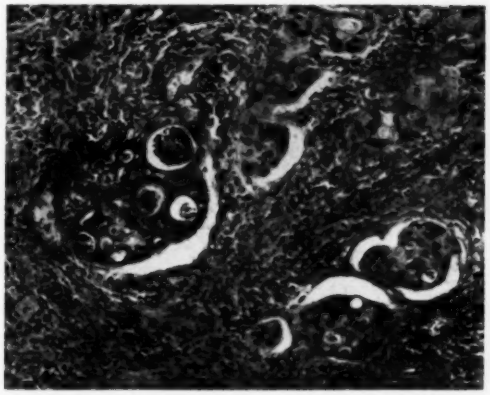

Fig. 10. Case 1. Section of cervix near external orifice showing nests of residual carcinoma deep in the wall. ×130.

The excised uterus was examined microscopically, and islands of residual carcinoma were seen in the endocervix, near the external os (Fig. 10).

Five months after operation, the patient was thin and complained of diarrhea and frequency of urination. There was moderate induration at the apex of the vagina with marked redness and yellowish discharge.

This case demonstrates that roentgen therapy can contribute effectively to the destruction of the undifferentiated forms of adenocarcinoma. On the other hand, a large radium exposure (8,000 mgm.hr.) failed to destroy all the tumor in the cervical myometrium.

CASE 2. Undifferentiated carcinoma of corpus uteri, advanced.

This patient, aged 67 years, white, was admitted on August 10, 1944, complaining of irregular vaginal bleeding for 9 months. Eighteen years previously, she had received radium for a fibroid tumor of the uterus, following which her menses ceased. She had had 3 children.

The patient was somewhat obese and her blood pressure was 190/100. The cervix was moderate in size, firm and closed. The uterus was four times normal size, enlarged more to the left, and freely movable. No adnexal masses or induration were detected.

At time of curettage, the uterine canal measured 12.5 centimeters and contained a large amount of yellow friable tissue which proved to be undifferentiated adenocarcinoma on histologic examination (Fig. 11).

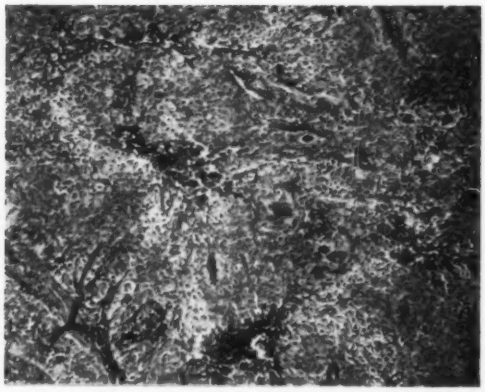

Fig. 11. Case 2. Section of tumor before therapy showing an extremely undifferentiated carcinoma. The cells are compactly arranged in solid sheets with thin vascular trabeculae coursing throughout. ×63.

The first radium treatment was given on August 18, 1944. By means of a three-piece hysterostat, 12 capsules of 10 milligrams each were inserted in triangular arrangement. The dose was 5,760 milligram hours (Fig. 12).

Fifteen days later, another curettage was performed preparatory to the second radium treatment. The uterus had shrunk, the canal now measuring 9 centimeters. A large amount of yellow, friable, chiefly necrotic tissue was removed, apparently from every portion of the corpus. Histologic examination of this tissue revealed considerable necrosis of the tumor cells, but some islands in the

Fig. 12. Case 2. Roentgenograph of hysterostat containing 12 radium capsules. First radium treatment. Uterine canal 12.5 centimeters long, fundus 4.5 centimeters wide, irradiated with angular crosspiece.

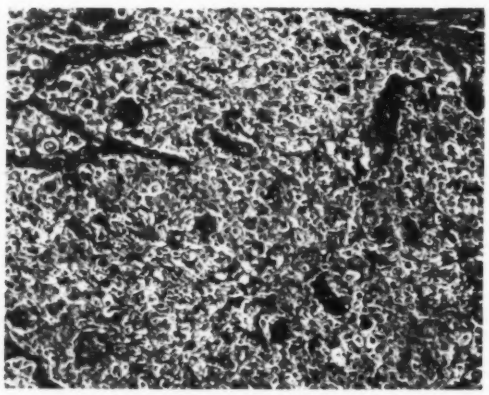

Fig. 13. Case 2. Fragments of tumor 15 days after first radium treatment of 5,760 milligram hours. Moderate swelling and vacuolation of the cytoplasm are noted in area shown. In other fields a moderately differentiated papillary pattern was noted showing milder radiation effects. ×63.

undifferentiated portion of the tumor showed moderate swelling and vacuolation of the cytoplasm (Fig. 13). A few areas with a differentiated papillary pattern, not seen in the original biopsy, showed little effect from radiation.

With the three-piece hysterostat in a different, but still triangular arrangement, 12 capsules of 10 milligrams each were inserted in the uterus and a dose of 6,720 milligram hours was administered. The total exposure in the two treatments was 12,480 milligram hours.

Forty-four days after the second radium treatment, panhysterectomy and bilateral salpingo-oophorectomy were performed. The peritoneum and intestines appeared normal. There were no enlarged lymph nodes along the aorta or beneath the pelvic brim. The uterus was smaller than normal and freely movable; both tubes and ovaries were atrophic. In pulling up the uterus, moderate tension being used, the uterine veins were torn on each side and considerable bleeding ensued. The veins were rather small but thin-walled and friable. The parametrial tissues were moderately friable, and sutures had a tendency to tear through the tissue. The postoperative course was uneventful and the patient was discharged on the 29th day.

Histologic examination revealed no evidence of residual tumor in the uterus, tubes, or ovaries. The

Fig. 14. Case 2. Uterus removed 44 days after second radium treatment. Total dose of 2 treatments 12,480 milligram hours. Note hemorrhagic and necrotic membrane completely covering the uterine cavity.

uterine cavity was lined with a thick hemorrhagic and necrotic membrane (Figs. 14 and 15).

Two months after operation, the patient complained of increasing pain radiating down the back and side of the left leg, and there later appeared marked edema of the leg. Six months after operation, a firm, fixed mass was felt in the lateral left lower abdomen above the inguinal region, also edema of the left arm, the cause of which had not yet manifested itself.

There are several distinctive features to this case. The first radium dose of 5,760 milligram hours which is ordinarily considered adequate for an undifferentiated tumor, was ineffective in that moderate radiation effects were seen in the undifferentiated part of the tumor but only slight effects in the differentiated part. Shrinkage of the uterus brought the pe ipheral portions of the tumor closer to the radium sources during the second radium administration. The reduction in length of the uterine canal from 12.5 centimeters to 6.5 centimeters is noteworthy.

The total radium dose of 12,480 milligram hours is remarkably large and apparently effectively eradicated the uterine tumor.

CASE 3. Moderately undifferentiated adenocarcinoma corpus uteri, advanced.

This patient, white, aged 54 years, was admitted March 10, 1944, complaining of continuous vaginal bleeding for 2 months. Menses had been normal and regular until menopause April, 1943. She had had 2 children.

The patient was in fair general condition. Bulging from the cervical canal, which was dilated to about 4 centimeters, was a grayish-red, granular, friable tumor attached to the posterior and right lateral surface of the endocervix and extending well up into the uterus. The corpus was two and one-half times normal size, in midposition, and free.

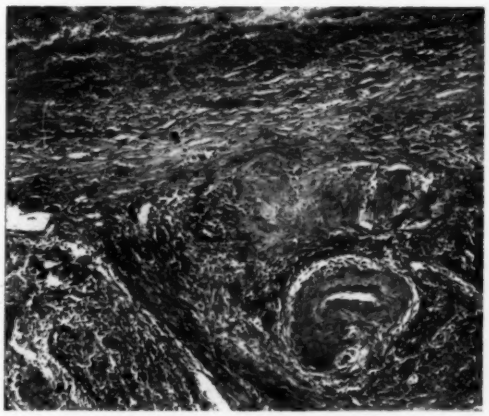

Fig. 15. Case 2. Typical section of uterus shown in Figure 14. Note the organizing hemorrhagic membrane resting directly on the compact, atrophic myometrium. No residual carcinoma found in this case. ×47.

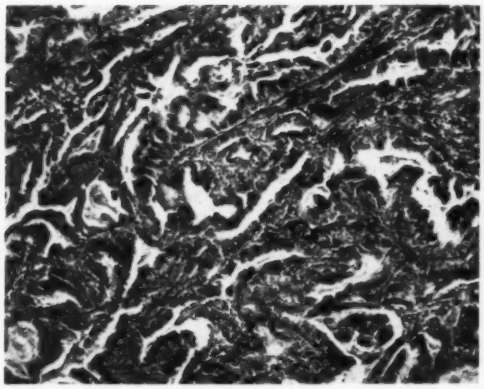

Fig. 16. Case 3. Curettage before therapy showing typical zone of moderately undifferentiated adenocarcinoma. While there is a definite alveolar arrangement, in many areas the cells are grouped in compact masses with frequent abnormal mitoses. ×63.

Posteriorly, on the right side, there was slight thickening. Biopsy revealed moderately undifferentiated adenocarcinoma (Fig. 16).

The presenting tumor was curetted. The canal was 9 centimeters long. A three-piece hysterostat containing 10 capsules of 15 milligrams of radium each was introduced into the uterine cavity (Fig. 17). A dose of 6,450 milligram hours was given.

The second radium treatment 18 days later, consisted of the introduction of three corks containing a total of 55 milligrams of radium in the vagina against the cervix. The dose was 3,960 milligram hours. The total radium dose was 10,410 milligram hours.

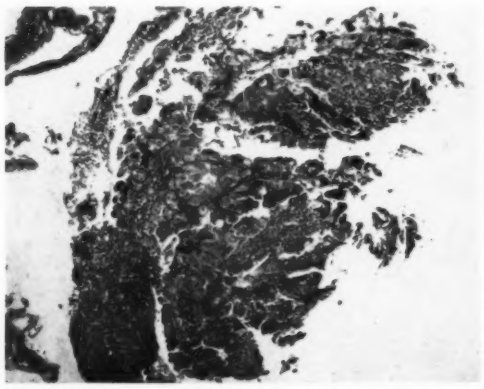

Fig. 18. Case 3. Curettage 18 days after 6,450 milligram hours intrauterine radium showing one of several nests of residual, moderately undifferentiated carcinoma. There is slight radiation effect. ×63.

Fig. 17. Case 3. Hysterostat containing 10 radium capsules of 15 milligrams each. Uterine canal 9 centimeters long. Dose, 6,450 milligram hours.

Examination at the time of the second radium treatment showed the cervix to be of moderate size and closed. The uterus was twice normal size and free. There was definite thickening in the right uterosacral ligament. The uterine canal measured 8 centimeters. A large amount of yellow necrotic tissue was removed with the curette. Microscopic examination (Fig. 18) revealed islands of carcinoma showing slight radiation changes in the midst of considerable necrotic tissue.

Thirty-nine days after the vaginal radium treatment, panhysterectomy, bilateral salpingo-oophorectomy, and appendectomy were performed. Catheters had been placed in the ureters. The peritoneum and intestines appeared normal. One lymph node 2 centimeters in diameter was densely adherent to the aorta, 4 centimeters above the level of the umbilicus, and was not excised. One lymph node in the right hypogastric area, 1 centimeter in diameter, was excised. The uterus was slightly enlarged and irregular. The tubes were normal. The right ovary was 5 centimeters in diameter, slightly yellowish, with a thickened capsule; the left ovary was atrophic. The right uterine vessels were ligated far laterally, laying the ureter to the side and taking the broad ligament tissues on the right. On the left, a conservative approach was made, going straight down along side the cervix. The patient was discharged 36 days after operation.

Histologic examination of the excised tissue revealed small islands of viable-appearing carcinoma

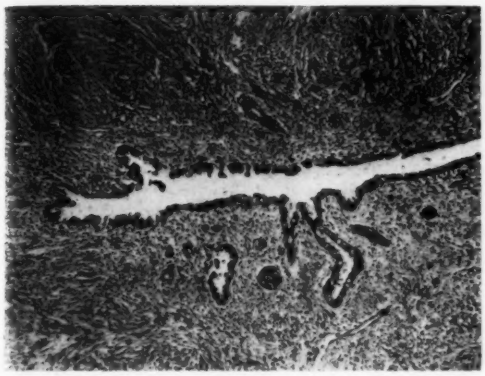

Fig. 19. Case 3. Section of uterus removed 81 days after intrauterine dose of 6,450 milligram hours and vaginal dose of 3,960 milligram hours radium, showing one of the residual neoplastic foci infiltrating the myometrium. The neoplastic cells form tubular structures and show moderate radiation effects. ×63.

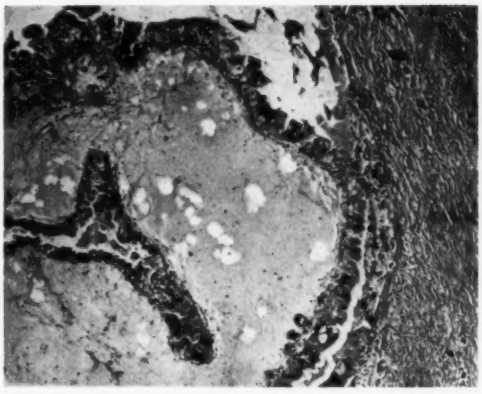

Fig. 20. Case 3. Metastatic papillary cystic lesion in right ovary lined with large polygonal and columnar cells showing bizarre nuclear changes. The pleomorphism and the nuclear alterations are probably the effects of radiation. ×45.

infiltrating the superficial myometrium in 8 of 10 blocks taken from the corpus (Fig. 19). In the right ovary there was a cystic, metastatic lesion 3 by 3.5 centimeters (Fig. 20). The hypogastric lymph node showed hyperplasia but no carcinoma.

A postoperative course of roentgen therapy (1,000,000 volts) was given to the pelvis. The skin dose was 4,000 r to each of four pelvic portals. This delivered a tissue dose in each broad ligament of 3,160 r over a period of 72 days. Subsequently, a second course of roentgen therapy was delivered through four portals crossfiring the preaortic node. The skin dose was 4 x 3,000 r; the tumor dose 5,400 r. There was no evidence that this node contained metastatic carcinoma. Eleven months after operation, the patient felt well and was quite active.

The intrauterine radium dose was 6,540 milligram hours followed by a vaginal radium dose of 3,960 milligram hours. Nevertheless, 81 days after the intrauterine radium treatment, the superficial layers of the myometrium were infiltrated by residual carcinoma, which was differentiated, in the form of tubular structures.

CASE 4. Moderately undifferentiated adenocarcinoma corpus uteri, early.

This patient, aged 59 years, white, was admitted on July 23, 1944, complaining of moderate vaginal bleeding on one day, July 16, 1944. Menopause had occurred 8 years previously. She had had 7 children, the youngest then 22 years of age.

The patient was of moderate build. The vagina was thin with some varicosities. The cervix was small and reddened about the closed os. The uterus was small, in midposition, and free; there was no adnexal mass or induration. The uterine canal measured 6.5 centimeters at the time of curettage. Many small pieces of grayish white tissue were removed.

Microscopic examination showed moderately undifferentiated adenocarcinoma (Fig. 21), generally forming large glandular structures, but with occasional scattered compact groups of neoplastic cells, and a moderate number of mitotic figures.

One week later, radium was introduced into the uterine cavity with a 3 piece hysterostat that contained 6 capsules of 15 milligrams each. A total dose of 6,030 milligram hours was given. This represented a dose of 1,005 milligram hours per capsule.

Forty-five days after the radium treatment, panhysterectomy and bilateral salpingo-oophorectomy were performed. The peritoneal surfaces and intestines appeared normal. No enlarged lymph nodes were felt along the aorta or under the brim of the pelvis. The uterus was small; the tubes and ovaries atrophic. The tissues of the broad ligaments, cardinal ligaments, and vagina were friable and easily torn. The postoperative course was complicated by partial intestinal obstruction and an abscess in the abdominal incision. The patient was discharged 35 days after operation.

The uterine wall averaged from 1.5 to 2 centimeters in thickness and the cavity was lined throughout with a creamy yellowish-green necrotic membrane, 1 to 2 millimeters thick. In 4 of 7 blocks, residual carcinoma in the superficial myometrium formed large glandular structures with an occasional island of undifferentiated cells showing moderate swelling of the cytoplasm (Fig. 22). In other areas, deep in the myometrium, were seen numerous small spaces, some partially lined with neoplastic cells of bizarre form.

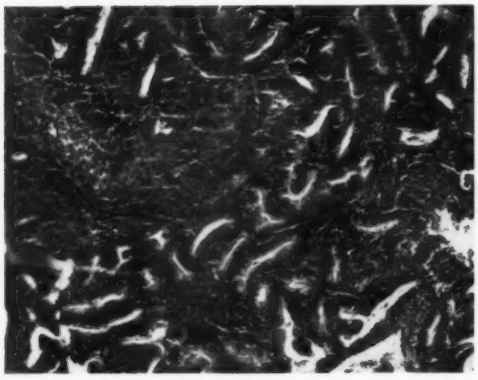

Fig. 21. Case 4. Biopsy before radium showing moderately undifferentiated adenocarcinoma. In other fields a more solid medullary arrangement of the cells was seen, similar to that noted along one edge of the photomicrograph. ×63.

Five months after operation, the patient felt well and was fairly active. There were no masses or tenderness in the abdomen, and the incision was well healed. The vagina was slightly thickened at the apex. The broad ligaments were soft.

CASE 5. Undifferentiated adenocarcinoma of corpus uteri, advanced.

This patient, aged 50 years, white, was admitted on August 31, 1943, complaining of brownish vaginal discharge daily for a year. She continued to menstruate regularly every 28 to 30 days. The flow was moderate, without pain, and lasted 4 days. She had 2 children, the youngest 23 years old.

Examination showed a well nourished patient. The vagina was normal. The cervix was of moderate size with two minute polyps on the posterior lip. The uterus was twice normal size, irregular in outline, anterior, and free. The right ovary contained a small cyst 4 centimeters in diameter; the left ovary was atrophic. There was no induration in the pelvis.

Under anesthesia, the polyps were excised. The uterine canal measured 9 centimeters. The cavity was gently curetted. A large amount of friable granular grayish-yellow tissue was obtained, apparently from every part of the corpus. Microscopic examination showed the cervical polyps to be benign; the endometrial tissue was for the most part undifferentiated adenocarcinoma (Fig. 23), while in a few fragments, the neoplastic cells were differentiating into glandular structures (Fig. 24).

Intracavity radium was administered with a 3 piece hysterostat, containing 10 capsules of 15 milligrams each (Fig. 25). The uterine cavity was large, the canal being 9 centimeters long, and the fundus 3.5 centimeters wide. For extraneous reasons, a dose of 7,000 milligram hours was given, instead of the dose of 10,000 milligram hours which had originally been contemplated.

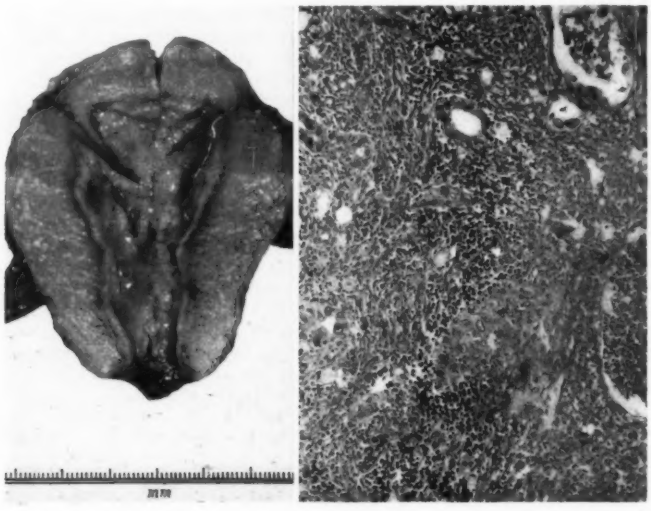

Fig. 22. a, left, Case 4. Uterus removed 45 days after 6,030 milligram hours radium. The diffuse pseudodiphtheritic lining membrane demonstrates the homogeneity of the radiation, and the probable extensive involvement of the entire uterine cavity by the original tumor. b, Residual neoplastic glands in superficial myometrium of corpus. Note the compact undifferentiated masses of neoplastic cells. ×70.

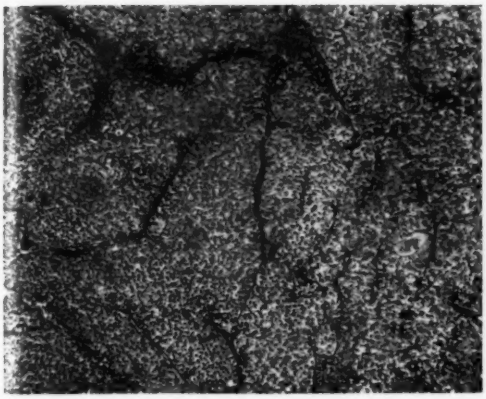

Fig. 23. Case 5. Curettage before therapy showing complete undifferentiation present in parts of the tumor. ×63.

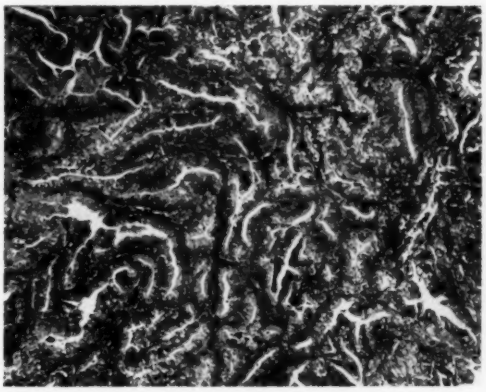

Fig. 24. Case 5. Section of another fragment showing a definite tendency of the cells to form glandular structures. Compare with Figure 23. ×63.

Thirty-eight days after the radium treatment, panhysterectomy and bilateral salpingo-oophorectomy were performed. The peritoneum and intestines were normal. No enlarged aortic or hypogastric lymph nodes were palpable. The uterus was slightly enlarged and free. The tubes and ovaries were atrophic. The cardinal ligaments and vaginal tissues were slightly edematous and felt fragile, but no technical difficulty was encountered. The postoperative course was uneventful, and the patient was discharged after 23 days.

The cavity of the uterus was somewhat expanded, with the canal measuring 7.5 centimeters (Fig. 26). Extending upward from the internal os, was a pseudodiphtheritic membrane, 3 by 4 centimeters in diameter and 3 to 4 millimeters thick. The upper posterior wall of the corpus was covered with a hemorrhagic membrane. Sections taken through the lower portions of the corpus revealed extensive carcinoma deep in the myometrium, the surface being covered with the thick pseudodiphtheritic membrane. Similar carcinoma infiltrating the myometrium was found in sections from each cornu, occurring for the most part as infiltrating sheets of cells, with little tendency to form alveolar structures. The effects of irradiation were mild to moderate, and included slight swelling of the cytoplasma and the presence of a moderate number of bizarre nuclear forms (Fig. 27).

Seventeen months after operation, the patient felt better than she had in years, and had gained 15 pounds. The abdomen was soft. The vagina was thin and pale, somewhat shortened, well healed, and with no residual thickening. The broad and uterosacral ligaments showed no induration.

This is a case of predominantly undifferentiated carcinoma similar to that in Case 2, in which a radium exposure of 7,000 milligram hours failed to destroy the carcinoma completely.

CASE 6. Moderately differentiated carcinoma of corpus uteri, moderately advanced.

This patient, aged 35 years, white, was admitted on December 31, 1944, complaining of vaginal bleeding which had continued for 18 months. Menarche occurred at 14, with intermittent menses until she was 16, when they ceased completely. In August, 1943, when the patient was 33, vaginal spotting began. After February, 1944, bleeding became almost constant. She had had dyspnea on exertion since youth.

Fig. 25. Case 5. Hysterostat containing 10 radium capsules of 15 milligrams each. Uterine canal measured 9 centimeters long; fundus measured 3.5 centimeters wide. Crosspiece contained two capsules.

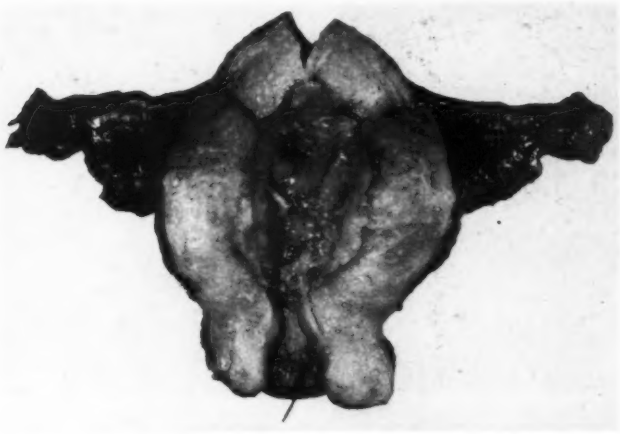

Fig. 26. Case 5. Uterus removed 38 days after 7,000 milligram hours of radium. Note the thick necrotic membrane covering the endometrial surface except for a triangular area on the posterior wall not covered by the hysterostat.

The patient was slender. Mitral stenosis with cardiac insufficiency was evident. The cervix was rather small, the os slightly dilated with a minute polyp high in the canal. The uterus was anterior, slightly enlarged, symmetrical, and freely movable. Both ovaries were normal in size and were free.

At time of curettage, the uterine canal measured 8 centimeters. A large amount of friable, yellowish tissue was obtained, apparently from every portion of the interior of the uterus. Intracavity radium was administered with a 3 piece hysterostat containing 7 capsules of 10 milligrams of radium each. A total dose of 7,000 milligram hours was given. Microscopic examination of the endometrium revealed moderately differentiated, infiltrating adenocarcinoma (Fig. 28).

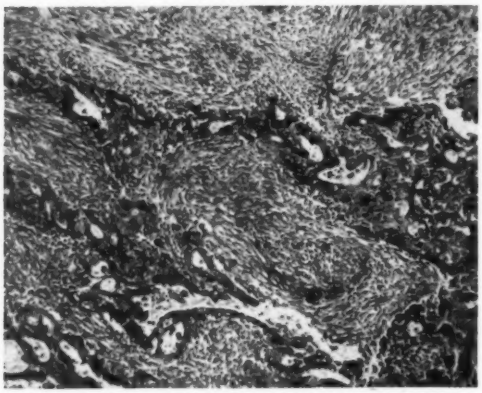

Fig. 27. Case 5. One of the several foci of residual carcinoma in the uterus shown in Figure 26. Extensive deep infiltration was found, generally by sheets of cells showing little tendency to form alveolar structures. Note the slight swelling of the cytoplasm and many bizarre nuclear forms. ×45.

Fifty-five days after treatment, panhysterectomy and bilateral salpingo-oophorectomy were performed. The peritoneum and intestines appeared normal. There were no enlarged aortic or hypogastric lymph nodes. The uterus was small and moderately atrophic; both tubes and ovaries were atrophic. There was no technical difficulty at operation. The excised uterus (Fig. 29) was small and firm with a narrow, tubular canal, approximately 1 centimeter in diameter and 6 centimeters long. The walls of the cavity were lined with firm, red granulations. There was no pseudodiphtheritic membrane. Microscopic examination showed, in 3 of 6 blocks, neoplastic glands infiltrating the myometrium. The effect of irradiation on the cells lining the alveoli was insignificant (Fig. 30).

The postoperative course was complicated by prolonged diarrhea and painful frequent micturition. After 2 months, the tissues at the apex of the vagina separated and formed an ulcer 3 centimeters in diameter. There was induration around the ulcer, particularly beneath the bladder.

The uterine cavity was not large; the radium distribution and dose (7,000 milligram hours) was adequate, according to our own concept of dosage; but there was residual carcinoma infiltrating the myometrium.

CASE 7. Moderately differentiated adenocarcinoma of corpus uteri, advanced.

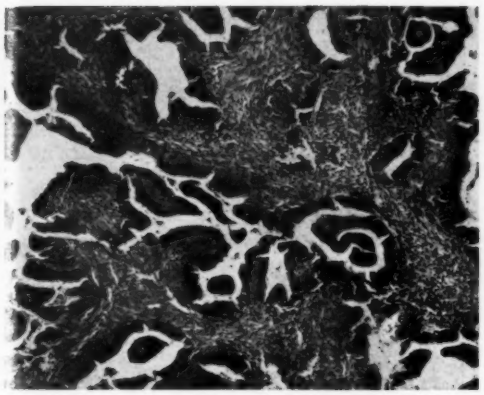

Fig. 28. Case 6. Fragments removed at time of diagnostic curettage composed of moderately differentiated neoplastic glands infiltrating the myometrium. ×63.

Fig. 29. Case 6. Uterus and adnexa 55 days after 7,000 milligram hours of radium. Note the small uterine cavity covered with a granulating membrane.

This patient, aged 67 years, white, was admitted on August 15, 1944, complaining of pink mucoid discharge for 18 months. The patient had four children, the youngest 22 years old. The menopause had occurred 20 years ago. One year ago, 6 x-ray treatments given elsewhere, stopped the pinkish discharge for 4 months.

The patient was obese and had hypertension (220/110) and arteriosclerosis. There were no abdominal masses or tenderness. The mucous membrane of the atrophic vagina was red; the cervix was small, firm and red. The uterus was in midposition and two one-half times normal size. No adnexal mass or induration was felt.

At time of curettage the uterine canal measured 8 centimeters. Microscopic examination of the tissue obtained revealed moderately differentiated infiltrating adenocarcinoma (Fig. 31).

One week later, a 3 piece hysterostat was inserted, containing 9 capsules of 10 milligrams radium each. The dose given at this first radium treatment was 4,500 milligram hours. Eight days later, the patient developed pelvic cellulitis, and at this time there was moderate induration in the rectovaginal septum and marked induration in the left broad ligament. The temperature and discomfort gradually subsided and the patient was discharged. Persistent pelvic induration caused the second radium treatment to be deferred.

Seventy days after the first radium treatment, the patient returned with no complaints and no bleeding. Penicillin was given prophylactically for 5 days. Under anesthesia the uterus was one and one-half times normal size and fairly movable. There were no palpable adnexal masses, but there was some thickening in the left uterosacral ligament. The uterus was thoroughly curetted. The endometrium was scant and the interior of the uterus was quite rough to the curette. At this time the uterine canal measured 6.5 centimeters. A 3 piece hysterostat containing 8 capsules of 10 milligrams radium each was inserted, and a dose of 4,400 milligram hours given (Fig. 32). The postoperative course was uneventful.

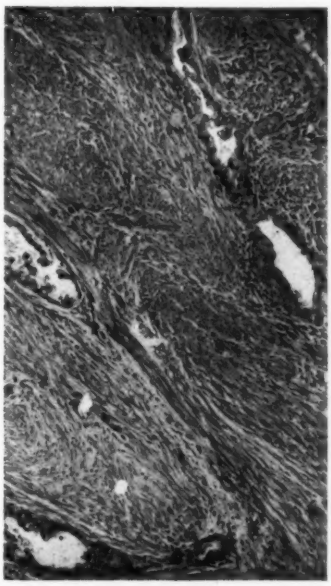

Fig. 30. Case 6. Low power showing one of the several residual areas of carcinoma infiltrating the myometrium. ×56.

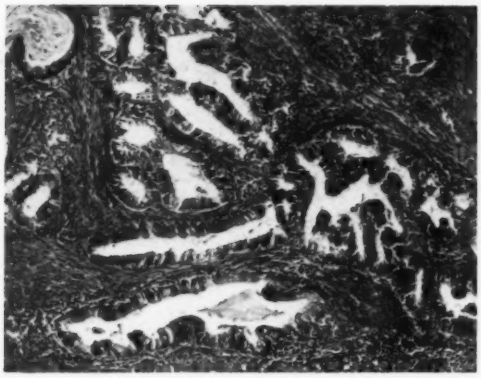

Fig. 31. Case 7. Biopsy before therapy showing moderately differentiated adenocarcinoma infiltrating the myometrium. ×63.

Curettage 75 days after the first treatment of 4,500 milligram hours dislodged only a few fragments of tissue; however, they consisted mostly of persistent adenocarcinoma infiltrating the myometrium and showing no demonstrable effects of irradiation.

Eight months after the first radium treatment, the patient felt well except for occasional bearing-down sensations in the lower abdomen. The uterus was smaller than normal; pelvic induration had diminished. Panhysterectomy and bilateral salpingo-oophorectomy were performed. The operative procedure was complicated by numerous post-inflammatory adhesions. There was marked chronic salpingitis, with moderate induration of the utero-sacral and left cardinal ligaments, fixing the uterus deep in the pelvis.

The uterus was small with a canal 4.5 centimeters long. The cavity was completely lined with a

Fig. 32. Case 7. Second radium treatment. Uterine canal has shrunken to 6.5 centimeters in length and fundus to 2.7 centimeters in width. Hysterostat now contains 8 capsules of 10 milligrams each. Dose 4,160 milligram hours. Total dose, 2 treatments, 8,900 milligram hours.

Fig. 33. Case 7. Uterus 6 months after second radium treatment. Uterine canal now measures 4.5 centimeters long (original length 8 centimeters). Note the uterine cavity completely lined with a shaggy, necrotic membrane.

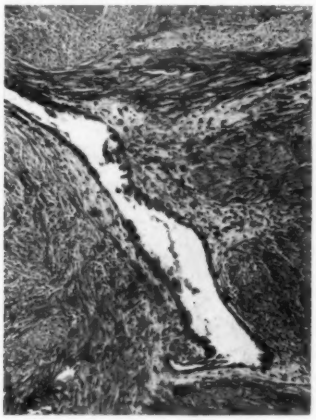

Fig. 34. Case 7. Section of uterus shown in Figure 33 with residual carcinoma deep in the myometrium. ×[illegible].

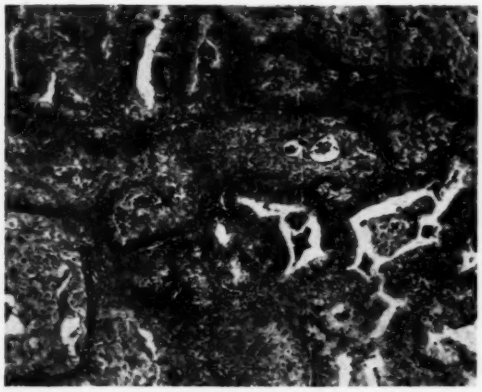

Fig. 35. Case 8. Fragments from diagnostic curettage made up entirely of solid masses of large polygonal neoplastic cells similar to the arrangement seen in Cases 2 and 5. In other areas the cells are differentiating into large glandular structures. Mitoses are numerous throughout with many abnormal forms. This is classified as a moderately undifferentiated adenocarcinoma. ×63.

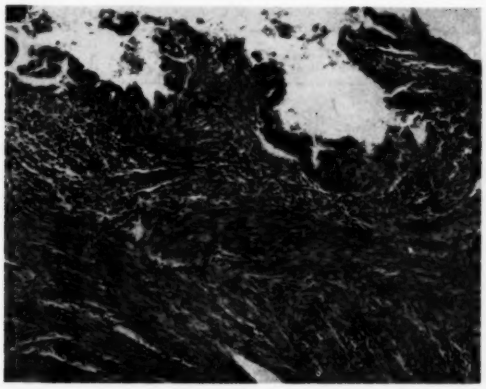

Fig. 36. Case 8. Section of uterus removed without usual preoperative course of radium showing residual zone of carcinoma in only one of the multiple sections taken. ×63.

shaggy membrane beneath which patchy areas of organization were seen. The myometrium was not significantly thinned and the vessels were prominent (Fig. 33). Microscopic examination of 14 serial, cross-section planes through the entire uterus revealed tumor in 2 sections of the midcorpus. The tumor was present as elongated glandular structures deep in the myometrium in one (Fig. 34), while in the other, the neoplastic cells were arranged in a solid nest.

The patient received a total dose of 8,900 milligram hours intrauterine radium in 2 treatments which brought about shrinkage of the uterus and disappearance of the symptoms. The outlook for arrest without hysterectomy seemed hopeful. However, the finding of residual tumor in the other cases had demonstrated the necessity of hysterectomy wherever possible. Therefore, operation was performed in spite of hypertension, obesity, diabetes, advanced age, and residuals of pelvic inflammation.

Residual carcinoma was present 75 days after the first radium treatment of 4,500 milligram hours, a dose which is considered adequate by many operators. Five and one-half months after the second radium treatment of 4,400 milligram hours, several small islands of residual cancer could still be found deep in the myometrium. They might have remained dormant during the rest of the patient's life span, but their removal increased the possibilities of a cure.

CASE 8. Moderately undifferentiated adenocarcinoma, early, almost completely removed at original biopsy curettage, surgical treatment only.

This patient, aged 39 years, white, was admitted to the hospital December 4, 1944. Menses had customarily lasted 4 days with moderate flow. However, she had a prolonged menstrual period lasting 8 days in August and again in November and December, 1944. There was no intermenstrual bleeding.

The vagina appeared normal; the cervix was smooth, firm, and closed. The corpus was small and free; the ovaries normal.

The uterus was curetted thoroughly, and a moderate amount of soft grayish tissue was obtained. Microscopic examination revealed moderately undifferentiated adenocarcinoma (Fig. 35). Panhysterectomy and bilateral salpingo-oophorectomy were performed. There was no evidence of extension or metastasis. The uterus, tubes, and ovaries appeared normal.

The interior of the uterus seemed normal when inspected grossly; but on microscopic examination one minute neoplastic focus was found, others apparently having been curetted away (Fig. 36).

The postoperative course was uneventful; 3 months later, the patient was well and showed no evidence of disease.

This is an early case of moderately undifferentiated adenocarcinoma of the uterus treated only by extirpation of the uterus, tubes, and ovaries. The curettage for biopsy almost completely removed the tumor.

TABLE I.—SUMMARY OF CASES

Case No.	Age	Duration symptoms	Type adenocarcinoma	Preoperative radiation	Interval radium to panhysterectomy	Pathology after operation	Follow-up since first treatment
1	30	3 mo.	Moderately undifferentiated (endocervix)	X-ray tumor dose 3030 r; 8000 mgm. hr. in uterus and vagina	66 days	Islands carcinoma endocervix	8 mo. No recurrence
2	67	9 mo.	Undifferentiated	12,480 mgm.hr.	44 days	No carcinoma	10 mo. Lateral pelvic recurrence
3	54	2 mo.	Moderately undifferentiated	10,410 mgm.hr. (6450 mgm.hr. in uterine cavity; 3960 mgm. hr. in vagina)	39 days	Islands carcinoma uterus and right ovary	14 mo. No recurrence
4	59	1 wk.	Moderately undifferentiated	6030 mgm.hr.	45 days	Islands carcinoma uterus	10 mo. No recurrence
5	50	12 mo.	Undifferentiated	7000 mgm.hr.	38 days	Islands carcinoma uterus	21 mo. No recurrence
6	35	18 mo.	Moderately differentiated	7000 mgm.hr.	55 days	Islands carcinoma uterus	5 mo. No recurrence
7	67	18 mo.	Moderately differentiated	8900 mgm.hr.	6 months	Islands carcinoma uterus	9 mo. No recurrence
8	39	4 mo.	Moderately undifferentiated	None	———	Superficial island carcinoma	6 mo. No recurrence
9	58	Several yrs.	Moderately differentiated	None	———	Advanced carcinoma uterus with metastases both ovaries	Died 6 mo. metastases
10	45	6 mo.	Moderately differentiated	None	———	Adenocarcinoma uterus with ovarian metastasis	4 mo. No recurrence

CASE 9. Moderately differentiated adenocarcinoma corpus uteri, advanced, with metastasis to ovaries.

This patient, aged 58 years, white, was admitted on August 11, 1942, with a history of daily bloody spotting from the vagina for many years. Menses ceased at 40 years.

The patient weighed 200 pounds. Abdominal palpation revealed large masses rising from the pelvis to the level of the umbilicus. The cervix was high in the vagina, smooth and closed. The fundus could not be distinguished from the lower abdominal masses. There was no induration or fixation of the pelvic floor.

At operation, the uterus was two and one-half times normal size, soft and nodular. Both ovaries formed large cystic lobulated tumors, 25 centimeters and 10 centimeters in diameter. The ovarian tumors, fallopian tubes, and supracervical portion of the uterus were excised with difficulty.

Microscopic examination revealed extensive, infiltrating, moderately differentiated adenocarcinoma of the uterus with bilateral ovarian metastases.

Sixteen days later, radium was inserted into the cervix and vagina for a total dose of 3,600 milligram hours. An incomplete course of postoperative roentgen therapy was given elsewhere. Six months later, the patient died with peritoneal carcinomatosis, ascites, and a large metastatic retroperitoneal tumor.

This patient is recorded as an instance of ovarian metastasis, the significance of which will be discussed later.

CASE 10. Adenocarcinoma corpus uteri, with ovarian metastasis.

This patient, aged 45 years, white, had constant vaginal bleeding from July, 1944, until January 15, 1945, when a total hysterectomy was performed at another hospital, for adenocarcinoma of the uterus. On admission to this hospital in March 29, 1945, no pelvic masses were palpable. Because of the frequency of ovarian metastasis, the abdomen was reopened. Although no obvious metastasis was observed, both tubes and ovaries were removed. Gross examination of the cut surface of the right ovary and microscopic examination revealed secondary adenocarcinoma.

This case demonstrates the necessity for oophorectomy as part of the routine treatment of adenocarcinoma of the uterus. The use of radium alone is attended by the danger of neglect of ovarian metastasis.

ANALYSIS OF CASES

In this series of 10 cases of adenocarcinoma of the uterus, 9 were moderately advanced or advanced, but without induration of the pelvic ligaments, and were therefore considered operable. Carcinoma protruded from the cervical os in two uteri; and ovarian metastasis was subsequently found in 3 patients. Microscopic examination revealed moderate differentiation (grade 2) in 4 cases, moderate un-

differentiation (grade 3) in 4 cases, and complete undifferentiation in 2 cases. This distribution is atypical, in that most large series have shown the majority of cases to be differentiated adenocarcinoma.

In 7 of the 10 cases, treatment with radium was followed by panhysterectomy and bilateral salpingo-oophorectomy. The radium dose ranged from 6,030 to 12,480 milligram hours. Case 1 (the only instance of adenocarcinoma of the endocervix) had an x-ray tumor dose of 3,030 r followed by 8,000 milligram hours of radium.

The size of the uterus was moderately or greatly reduced following radium. In Case 7, for example, the uterine canal shrank in length from 8 to 4.5 centimeters; in Case 2, the uterine canal shrank from 12.5 centimeters to 6.5 centimeters.

The operative procedure was not unduly difficult except in Case 7, in which the residuals of pelvic inflammation complicated the operation. In every instance the parametrial tissues were somewhat sclerotic, with lack of resiliency, and the sutures had to be tied with care. The uterine vessels seemed smaller than usual. In one instance, the uterine veins were torn on each side as the uterus was being elevated. The Richardson conservative panhysterectomy technique was used in all except Case 3 in which a radical dissection was performed on the right side only because of slight preradiation thickening in the right uterosacral ligament.

Interesting was the finding of nests of apparently viable cancer cells in the superficial myometrium in 6 of the 7 excised uteri, with deeper extension in 3. The one uterus (Case 2), in which no residual carcinoma was found, had a highly malignant, undifferentiated adenocarcinoma which received 12,480 milligram hours of radium, given in 2 exposures.

The location of residual carcinoma deep in the myometrium explains why probatory curettage performed several months after radium treatment in order to evaluate its effectiveness, may fail to extract the residual carcinoma.

It is possible that, after irradiation, some of this residual carcinoma might not have manifested itself clinically for 5 years or longer. However, hysterectomy is necessary to complete eradication of the local tumor.

Reasons why the combined radium-surgical treatment gives the best results, according to the literature, include: (1) reduction of intrauterine infection preoperatively, (2) reduction in size of the uterus simplifying the operative procedure, (3) immobilization of cancer cells in the uterus reducing metastasis, (4) sclerosing of lymphatics and blood vessels, reducing metastasis, (5) prevention of recurrence from operative spill in the vagina and abdominal incision, and (6) favorable results borne out of statistical evidence.

Statistical evidence, however, is the only concrete information on the value of preoperative radiation. The available statistics discussed previously are based on small series, varying from 10 to 37 cases. The 5 year arrests range from Sheffey's 38.4 per cent in 30 cases to Arneson's 90 per cent in 10 cases. Series of as many as 100 cases with uniform radium treatment, in doses of 4,000 milligram hours or more, should be available before the rôle of preoperative irradiation can be evaluated.

Preoperative roentgen therapy has been recommended by some, notably Miller, who emphasizes the additional destruction of tumor cells in the parametrium by this method. However, the intensive x-ray therapy necessary to give a lethal tumor dose may cause destructive changes in the bowel, and adhesions. The immediate postradium complications following the use of large doses were not serious. The one instance of acute pelvic cellulitis (Case 7), followed a relatively small radium dose of 4,500 milligram hours. However, the later deleterious effects of intrauterine radium in the large doses employed in this series are not to be overlooked. Postoperative hospitalization is lengthened. Recovery of vitality is often delayed for months. There may be delayed healing of the vaginal wound, intermittent diarrhea, and frequency of urination. If the eventual cure rate is increased, these disadvantages can be disregarded.

One patient (Case 8) had undifferentiated adenocarcinoma for which many authors recommend preoperative radium. The short

history, scant endometrium, and small uterus indicated an early lesion. Hysterectomy was performed without preliminary radium. Three patients (Cases 3, 9, and 10) had metastasis in the ovary. This not uncommon incidence of ovarian metastasis is frequently overlooked in planning therapeutic procedures for adenocarcinoma of the uterus. It constitutes an important argument against the use of radium alone in the treatment of this disease. Preoperative radium cannot materially affect the metastatic lesion in the ovary. Consequent postradium hysterectomy should not be unduly delayed.

SUMMARY

Ten patients with adenocarcinoma of the uterus were treated in the past 3 years at Walter Reed General Hospital. Seven patients received unusually large doses of radium (6,030, 7,000, 7,000, 8,000, 8,900, 10,410, 12,480 milligram hours) followed by hysterectomy 38 days to 6 months later. Six of these 7 uteri showed residual carcinoma. The one case in which there was no remaining carcinoma after radium, was an extensive undifferentiated tumor in a large uterus, treated with 12,480 milligram hours radium. One patient with very early undifferentiated adenocarcinoma was treated with surgery alone. Three patients had ovarian metastasis.

CONCLUSION

1. This study suggests that radium alone will not completely eradicate adenocarcinoma of the uterus. Subsequent excision of uterus, tubes, and ovaries is necessary.

2. The exact rôle and specific indications for preoperative radium therapy have not yet been satisfactorily delineated.

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PRACTICAL OBSERVATIONS ON THE COPPER SULFATE METHOD FOR DETERMINING THE SPECIFIC GRAVITIES OF WHOLE BLOOD AND SERUM

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THE clinical significance of the measurement of the specific gravities of whole blood and plasma or serum has been discussed by Barbour and Hamilton, Weech *et al.*, Scudder, Kagan, Ashworth and Adams (1), Gray and Elliot, Phillips *et al.* Technical complications have at times offered impediments to the routine clinical application of several methods, particularly in a military sense. The authors of the copper sulfate technique (Phillips, Van Slyke, Dale, Emerson, Hamilton, and Archibald) point out that this is a technically simple, quickly conducted procedure which maintains a sufficient degree of accuracy under the usual variable circumstances to give it much clinical applicability. In the present communication it is proposed to present additional evidence in support of the practical use of the copper sulfate values of whole blood and serum specific gravities.

METHODS

The copper sulfate solutions were prepared as outlined by Phillips and co-workers. The stock solutions (specific gravity 1.1) were checked periodically by pycnometric procedures. At times, when solutions were prepared aboard ship, pycnometry was not possible and the fresh standard solutions were checked via a series of normal samples with previously pycnometrically checked solutions. It was possible at other times to compare our solutions with those prepared by Army laboratory facilities ashore. The constancy of checks established much confidence in the technique.

This work was commenced at the suggestion of and progressed under the direction of the senior author, Fleet Medical Officer, Staff Commander, Allied Naval Forces, Southwest Pacific Area.

Altogether 16 different batches of the stock solution were used in preparing the various standard sets used in the observations.

For the actual determination the following procedure was used throughout: venous blood was collected in a dry syringe (5 to 20 c.c. capacity) while stasis was limited as much as possible and drops from the syringe tip, before clotting occurred, were used for measuring the blood specific gravity; the remainder of the blood was allowed to clot in a test tube, spun in a centrifuge and the specific gravity of the serum was determined with the aid of a medicine dropper.

The Sahli hemoglobin measurements were conducted first with daylight, then with artificial light as background for color matching; 14.5 grams per cent were considered as 100 per cent normal. The red blood cell counts were done with routine type of equipment, 10 squares being counted on each occasion.

NORMAL VALUES

The normal series were taken from inactive, normal, healthy Army and Navy personnel (males), most of whom had been established in "staging areas" at sea level in tropical localities for weeks to months. The samples were taken throughout the day prior to which time the individuals had been ambulatory for varying intervals.

The frequency distribution of the whole blood specific gravity values on 577 different individuals is given in Table I. The following features of these data are emphasized: The over-all range is 1.052 to 1.064 with only one value falling in each of these extremes; the arithmetic mean value 1.0581; the standard deviation (σ) is 0.0019; the mean $\pm 2\sigma$ equals 1.0543 to 1.0619.

The frequency distribution for the serum values on 574 of the above 577 samples is also given in Table I. The range for these values is 1.024 to 1.030 with only one value occurring below 1.025; the mean is 1.0273; the σ equals 0.0013; the mean $\pm 2\sigma$ equals 1.0247 to 1.0299.

These normal values have been taken as the basis for evaluating values obtained from subjects under various abnormal states in tropical zones (New Guinea to the Philippine Islands). It has been considered safe to state that blood specific gravity values by this technique outside of the range of 1.0543 to 1.0619 (mean $\pm 2\sigma$) are significant in denoting red blood cell dilution or concentration beyond normal limits. By the same token, serum specific gravity readings outside of the range 1.0247 to 1.0299 have been considered significant in denoting dilution or concentration of the serum proteins beyond normal limits.[1]

TABLE I.—FREQUENCY DISTRIBUTION OF WHOLE BLOOD AND SERUM SPECIFIC GRAVITIES ON NORMALS.

Blood		Serum	
Sp. gr.	Frequency	Sp. gr.	Frequency
1.051	0		
1.052	1	1.023	0
1.053	3	1.024	1
1.054	12	1.025	20
1.055	35	1.0255	16
1.056	69	1.026	78
1.057	94	1.0265	45
1.058	122	1.027	128
1.059	108	1.0275	53
1.060	86	1.028	120
1.061	18	1.0285	30
1.062	15	1.029	62
1.063	13	1.030	21
1.064	1	1.031	0
1.065	0		
Total	577	Total	574

The whole blood values are entirely symmetrical. The lower frequency of the "half" values in the serum series is considered due to the technique which encourages "whole" values. For instance, the tendency is to take the "whole" value when the drop of serum acts as having a specific gravity between the "half" and the "whole" values.

SPECIFIC GRAVITY VALUES, RED CELL COUNT, HEMOGLOBIN CONCENTRATION (SAHLI): COMPARISON ON NORMALS

It will be noted in Table II that the Sahli hemoglobin concentration as read against artificial light averaged about 0.8 per cent higher figures than the comparisons read against daylight.

All three of these values (specific gravity of blood, hemoglobin concentration, red blood cell count) depend mainly on the concentration of red cells per unit of blood for their level, and so long as the methods of determination are reasonably correct one expects a satisfactory correlation between the values. The correlation obtained by the routine measures as demonstrated in Table II seems satisfactorily close and resembles similar correlations presented by Ashworth and Adams (1) and by Gray and Elliot utilizing other specific gravity and hemoglobin methods.

VARIATIONS IN SPECIFIC GRAVITY VALUES IN NORMAL SUBJECTS INDUCED BY VARIOUS SOLUTIONS ADMINISTERED INTRAVENOUSLY

The variations in the specific gravities of whole blood and serum samples from normal subjects over a 24 hour period effected by substantial volumes of physiologic saline solution, normal human plasma, concentrated human plasma (four fold concentration), and concentrated human albumin (25 grams per cent) given intravenously were observed. The results are presented in Figure 1 which also contains similar observations following a comparable volume of whole blood given a subject with slight hemodilution.

Considering that the specific gravity of whole blood is due mainly to the concentration of red cells and that the serum specific gravity is due mainly to the concentration of the proteins, certain observations are evident. Saline, normal plasma, concentrated plasma and concentrated albumin all gave rise to dilution of the recipients' red cells. Following the latter three solutions this dilution remained evident until 12 to 24 hours had passed when preinfusion levels were reached. For saline the dilution was evanescent and a preinfusion level was noted 90 minutes after the infusion. The protein-containing solutions (normal plasma, concentrated plasma, concentrated al-

[1]Significance is being given these ranges, means, and deviations mainly because significance has been given to findings from similar and related procedures in which inactive normals who had been ambulatory were compared with patients who were of a necessity of stretcher type. Yet it should be mentioned that physiologists point out that the plasma volume is somewhat lower in the erect posture than during recumbency due to the escape of a type of fluid from the circulation which tends to concentrate both the red cells and the serum proteins(4). The study of Perera and Berliner demonstrating a lowering of the serum protein concentration during the recumbency of sleep can be taken as an additional elaboration of this concept.

TABLE II.—COMPARISON OF SPECIFIC GRAVITY VALUES, HEMOGLOBIN CONCENTRATION BASED ON THESE VALUES AND TAKEN FROM THE PHILLIPS AND ASSOCIATES CHART; THE HEMOGLOBIN CONCENTRATION BY SAHLI'S TECHNIQUE, DAYLIGHT AND ARTIFICIAL LIGHT READINGS; AND THE RED BLOOD CELL COUNT

No.	Blood Sp. gr.	Serum Sp. gr.	Hgb. chart grams per cent	Daylight Sahli		Art. light Sahli		Rbc. mil.
				gms. per cent	per cent N	gms. per cent	per cent N	
1	1.057	1.0255	15.0	16.0	110	17.0	117.2	4.775
2	1.0555	1.0265	14.0	15.2	104.8	16.0	110	4.64
3	1.055	1.026	13.9	14.6	100.6	15.6	107.5	4.47
4	1.0545	1.0275	13.3	14.4	99.2	15.5	106.8	4.435
5	1.058	1.026	15.4	15.5	106.8	16.2	111.7	5.11
6	1.056	1.0265	14.2	16.0	110	16.5	113.8	4.94
7	1.0545	1.0265	13.4	15.9	109.6	16.1	111	4.31
8	1.0565	1.0255	14.8	15.5	106.8	16.0	110	4.93
9	1.055	1.0265	13.8	14.5	100	15.5	106.8	4.365
10	1.057	1.025	15.2	15.0	103.4	16.0	110	4.7
11	1.0555	1.025	14.4	15.2	104.8	15.5	106.8	4.74
12	1.0595	1.027	15.7	16.0	110	16.5	113.8	5.07
13	1.057	1.027	14.7	15.0	10^.4	15.9	109.6	5.15
14	1.055	1.026	13.9	15.0	103.4	15.3	105.5	4.355
15	1.0545	1.025	13.9	15.8	108.9	16.2	111.7	4.395
16	1.062	1.028	16.8	16.5	113.8	17.5	120.6	5.16
17	1.058	1.027	15.2	15.5	106.8	16.0	110	4.71
18	1.059	1.0265	15.8	17.0	117.2	17.5	120.6	5.17
19	1.056	1.0255	14.5	14.5	100	15.5	106.8	5.21
20	1.058	1.025	15.7	16.5	113.8	17.2	118.6	5.05
21	1.056	1.025	14.7	15.0	103.4	15.5	106.8	4.61
22	1.0575	1.0265	15.0	16.0	110	16.8	115.8	4.9
23	1.055	1.026	13.9	15.0	103.4	15.5	106.8	4.59
24	1.060	1.0265	16.1	16.5	113.8	17.0	117.2	5.67
25	1.062	1.027	16.9	17.0	117.2	17.5	120.6	5.54
26	1.059	1.026	15.8	16.5	114.8	17.2	118.6	4.86
27	1.056	1.025	14.8	16.0	110	16.5	113.8	4.81
28	1.056	1.026	14.3	14.5	100	15.0	103.4	4.85
29	1.058	1.027	15.2	17.0	117.2	17.5	120.6	5.37
30	1.055	1.026	13.9	15.0	103.4	15.5	106.8	4.7
31	1.0575	1.026	15.1	16.5	113.8	17.0	117.2	4.96
32	1.057	1.0245	15.3	16.0	110	16.5	113.8	5.3
33	1.0575	1.026	15.1	15.5	106.8	16.0	110	4.85
34	1.055	1.026	13.9	15.0	103.4	15.5	106.8	4.99
35	1.0565	1.027	14.3	15.0	103.4	15.5	106.8	5.14
36	1.059	1.027	15.6	15.0	103.4	15.5	106.8	5.56
37	1.0565	1.026	14.6	15.6	107.5	16.0	110	4.71
38	1.0555	1.026	14.1	15.0	103.4	15.5	106.8	4.58
39	1.063	1.026	17.7	18.5	127.5	19.0	131	5.64
40	1.058	1.027	15.1	15.0	103.4	15.5	106.8	5.15
Av.	1.057	1.0261	14.87	15.13	104.3	16.27	112.2	4.889

Abbreviations: Sp. gr., specific gravity; Hgb. chart, hemoglobin concentration as obtained from the Phillips chart; per cent normal when normal is taken as 14.5 grams per cent; Rbc. mil., red cell count expressed in millions; av., average.

bumin) produced little change in the serum protein concentration. Conversely, saline effected a marked drop in the protein concentration which returned to preinfusion levels only after some 6 hours had elapsed. Blood given to a subject with specific gravity values slightly below normal caused an elevation in the red cell concentration, the continuation of which must have become augmented by red cell production and liberation from active bone marrow areas. Little change occurred in the serum protein concentration from this infused volume of blood.

ISOLATED CASES ILLUSTRATING THE CLINICAL APPLICATION OF COPPER SULFATE SPECIFIC GRAVITY VALUES

The isolated cases used in demonstrating the clinical application of the specific gravity values were all battle casualties occurring in various engagements during the recent Philippine campaign. At present the emphasis is placed mainly on the specific gravity studies as they deviate from the normal. A correlation of such studies with other aspects of casualty care, as types and volume of intravenous solutions used, types of cases, response to therapy —with main consideration of the shock state —will be presented later in a compilation of over 300 closely observed cases out of some 5,000 casualties handled by our medical facility (16).

HEMORRHAGE

It has long been emphasized that the loss of whole blood from the circulation is followed by dilution of the remaining red cells. Whether there is dilution of the serum (or plasma) pro-

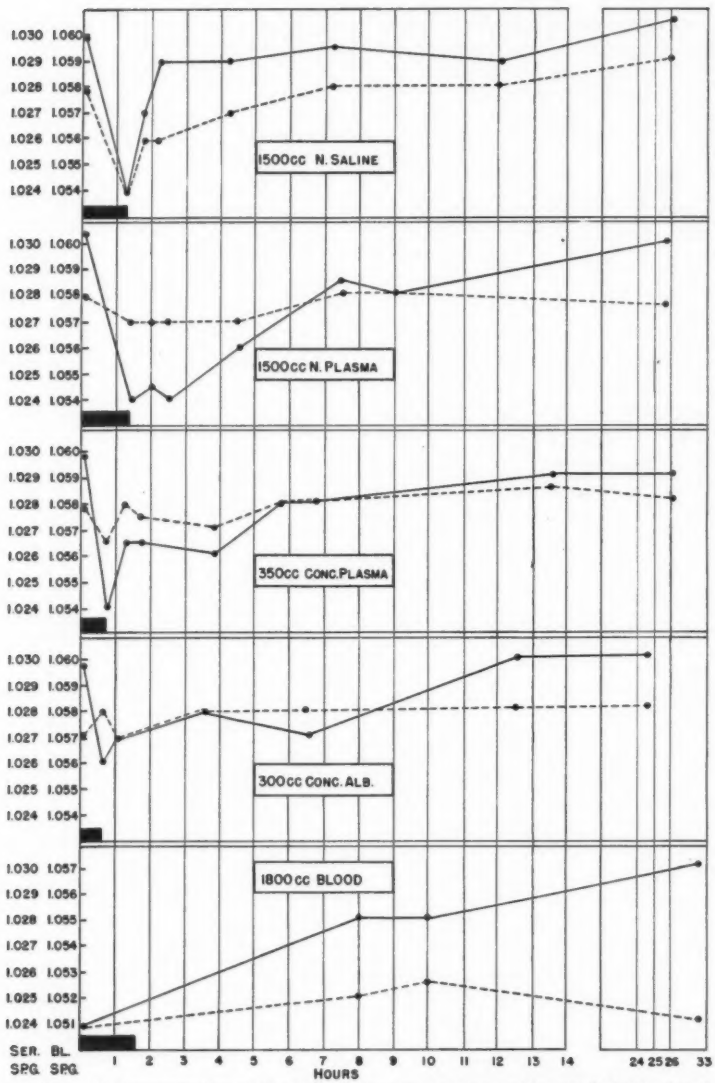

Fig. 1. A demonstration of the changes in the specific gravities of whole blood and serum induced on normal subjects by various commonly used intravenous fluids. Comparable volumes were used. The normal plasma, concentrated plasma, concentrated albumin solution each contained approximately 75 grams of proteins. The blood was diluted about 1 to 5 with citrate-dextrose anticoagulant preservative solution. The time interval for the infusion is designated at the lower left corner. The solid lines represent whole blood specific gravities, the broken lines serum specific gravities.

teins over a sustained period seems to depend on several factors as the extent of blood loss, the interval of time before a determination is made, the state of the protein stores, the demands on the protein stores by other complications, etc. The hemodilution commences

TABLE III.—SPECIFIC GRAVITY VALUES IN CASE 2

Time Hour	Blood Sp. gr.	Serum Sp. gr.	Hgb. chart	Ser. prot. chart	Therapy	Remarks
0	1.035	1.0255	4.5	6.3		Severe shock
6					200 c.c. c. alb.	Amputation performed
					3200 c.c. bl.	BP 110/80
					500 c.c. pl.	Out of shock
						2 gms. Ca gluconate with bl.
7.5	1.051	1.0275	11.6	7.0		P110 Satisfactory

The 2 grams of calcium gluconate were given in 2 doses between each liter of blood to prevent tetany due to the citrate in the blood.

The same scheme will be used on all subsequent tables: The zero hour represents the first time the patient was seen and appraised; Hgb. chart and ser. prot. chart represent the hemoglobin concentration in grams per cent and the serum protein concentration in grams per cent as taken from the Phillips and associates chart; various intravenous fluids are abbreviated as follows: pl., normal plasma; conc. pl., concentrated plasma (3–4 fold); c. alb., concentrated albumin solution (25 per cent), bl. citrated whole blood (1 to 4 and 1 to 5 dilution); D-S, 5 per cent dextrose in normal saline solution; D-H, 5 per cent dextrose in distilled water; at the time the quantity of intravenous fluid is designated in the table the administration has just been completed, having been started usually at the time the previous specific gravities were taken.

TABLE IV.—SPECIFIC GRAVITY VALUES IN CASE 3

Time Hour	Blood Sp. gr.	Serum Sp. gr.	Hgb. chart	Ser. prot. chart	Therapy	Remarks
0	1.045	1.022	10.5	5.15		
1.0						BP102/68 Shock
1.5					1100 c.c. bl.	
2.5						118/68
3.0					600 c.c. bl.	
4.5					1100 c.c. bl.	
12.5	1.051	1.025	12.3	6.2		

early but when compensation by the subjects own resources is all that induces it the final degree of dilution of the blood may not occur for 24 to 36 hours (7). During the first hour the dilution may not exceed 10 per cent (13), indeed in occasional patients with hemorrhagic hypotension it has been reported that there may be no dilution or actual concentration of the red cells (hemoconcentration) (6, 15). The administration of intravenous fluid not containing red cells, particularly protein fluids as plasma or albumin solutions, by their inherent properties accelerates the development of the final degree of hemodilution in hemorrhage cases (17).

The extent of the drop in blood specific gravity, the effect on the serum specific gravity, the state of the blood pressure, the clinical picture, the response to therapy (including the quantity and quality of the fluids used) are all important in estimating a case of acute blood loss clinically. Examples demonstrating the value of specific gravity studies will be divided into the patient (1) suspected of having a substantial hemorrhage; (2) with hemorrhage with embarrassment to the circulation; and (3) with hemorrhage followed by volume compensation (acute hemorrhagic anemia).

Following is an instance of a patient suspected of having a substantial hemorrhage.

CASE 1. This patient sustained multiple lacerations involving the skin and muscles of the upper extremities, back and legs: there was no fracture. He was seen about 4 hours after the injury, 250 cubic centimeters of normal plasma had been given intravenously. The specific gravity values were 1.054 for blood, 1.0265 for serum, the blood pressure was 120–80 millimeters hemoglobin, the pulse rate was 100 beats per minute, but the patient was restless, confused, the pulse was weak. Following 1,000 cubic centimeters of normal plasma by vein there was obvious clinical improvement and 7.5 hours later the specific gravity figures were 1.050 and 1.026. After 22 to 23 hours the specific gravities levelled off at 1.051 to 1.027, slightly lower than the normal range for the blood value.

The patient sustained injuries conducive to blood loss, the extent of which was unknown. The clinical improvement with plasma alone plus a stabilization of the blood specific gravity at levels only slightly below normal indicated a blood loss not of extreme proportions. Without the concentration studies complete confidence in this case would have been more difficult.

Hemorrhage with moderate to severe circulatory embarrassment. We are considering here the patient with tendency toward a lowered arterial pressure, weak pulse, restlessness or disorientation to coma, lowered urinary output, paleness with or without sweating, etc., following types of injury conducive to copious hemorrhages. Some have termed the state hemorrhagic shock (5), others prefer hemorrhagic hypotension applied to recoverable cases (22), while others object to applying the terms shock where simple hemorrhage appears to be the main complication (14). The demonstration of hemodilution by the copper sulfate method is our main concern at present.

TABLE V.—SPECIFIC GRAVITY VALUES IN CASE 4

Time Hour	Blood Sp. gr.	Serum Sp. gr.	Hgb. chart	Ser. prot. chart	Therapy	Remarks
0	1.0425	1.025	8.2	6.2		
2.5					1000 c.c. D-S 500 c.c. pl.	D-S pl. for urinary flow
20.5	1.042	1.025	8.0	6.2		
22					1100 c.c. bl.	
30	1.048	1.025	10.9	6.2		
32	1.049	1.026	11.1	6.5		
32.5					1100 c.c. bl.	
49.5	1.053	1.026	12.9	6.5		
50					550 c.c. bl.	
68	1.0555	1.025	14.5	6.2		

TABLE VI.—SPECIFIC GRAVITY VALUES IN CASE 5

Time Hour	Blood sp. gr.	Serum sp. gr.	Hgb. chart	Ser. prot. chart	Therapy
0	1.040	1.022	8.2	5.15	
0.25	1.040				
1.0					1100 c.c. bl.
3.0					1100 c.c. bl.
14	1.047	1.023	11.1	5.45	
15					1100 c.c. bl.
17					1100 c.c. bl.
22	1.057	1.025	15.2	6.2	
24	1.056	1.0255	14.6	6.3	

CASE 2. The first patient sustained severe injuries to the right leg following an attack on one of our ships. He was seen some 8 hours later at which time there were clinical indications of severe circulatory embarrassment; pulse too weak to be definitely palpable, semicoma, marked pallor, lowered skin temperature. The right leg was severely crushed and mangled and it was learned that the individual had been in the water (sea) some 45 minutes without a tourniquet before being rescued. Table III demonstrates marked hemodilution: Following the administration of concentrated albumin and whole blood (amount in table) there was much improvement, the right leg was amputated, additional blood and plasma were given and later the specific gravity of blood was only slightly below the normal range. The patient did well subsequently.

CASE 3. The second patient was seen 3 to 4 hours following the injuries, extensive shrapnel lacerations of the face, right arm, and right leg. The patient was weak, pale, cold, the pulse quite weak, the blood pressure 102/68. After 1,100 cubic centimeters of whole blood there was much improvement but a total of 2,800 cubic centimeters of blood was required to elevate both blood and serum specific gravity values to near the normal ranges (Table IV). The patient improved and progressed nicely.

Hemorrhage with acute posthemorrhagic anemia. This group includes the patients seen 2 to 3 days or longer following injuries producing blood loss and the final degree of hemodilution has been reached. At this time it is considered that an insufficient interval has elapsed in many cases for dietary and bone marrow depressing complications to affect the blood picture appreciably.

CASE 4. The first illustrative patient (Table V) was seen 2 days following the injury (gunshot wound with abdominal perforation, injury to left kidney and spleen, emergency splenectomy). The dilution of the red cells was prominent and it required 2,750 cubic centimeters of whole blood given in 48 hours time to elevate the specific gravity to normal levels.

CASE 5. The second patient was likewise seen 2 days following the injury by shell fragments causing laceration of the abdominal wall and perineum, perforation of the urinary bladder and rectum. On this occasion, there was dilution of both red cells and serum proteins (Table VI). The specific gravity values returned to normal range following 4,400 cubic centimeters of blood.

BURNS

Early phase. Here is included burn cases seen while there is increased permeability of capillaries giving rise to a decrease in the plasma volume and hemoconcentration (shock period).

CASE 6. The first patient was seen 8 hours following the burn (Table VII). He had received plasma intravenously prior to this time but the amount was not known. When seen there was pronounced concentration of the red cells as demonstrated by a blood specific gravity value well above the normal range. The extent of capillary damage and plasma volume depletion can be appreciated by the volume of protein solution required to lower the blood specific gravity to normal levels.

CASE 7. The second case is presented mainly because it reveals the highest blood specific gravity values seen. This patient came under our observation 4 hours after severe burns involving the entire body surface with the exception of about 20 per cent of the left arm and the area covered by swimming trunks. The left leg was parched, the foot blue and cold. The patient was in deep shock, unconscious, the pulse not palpable, the skin about the genitalia cold and prominent with bluish-gray mottling. The first blood samples (from femoral veins) were exceedingly thick and almost black in color (specific

TABLE VII.—SPECIFIC GRAVITY VALUES IN CASE 6

Time Hour	Blood Sp. gr.	Serum Sp. gr.	Hgb. chart	Ser. prot. chart	Therapy
0	1.068	1.0255	20.2	6.3	
8	1.059	1.025	16.0	6.2	400 c.c. c.alb. 750 c.c. pl.
20	1.059	1.0255	15.9	6.3	200 c.c. c.alb. 750 c.c. pl. 500 c.c. D-H
34					200 c.c. c.alb.
35	1.057	1.0275	14.5	7.0	

gravity 1.074). The tremendous quantities of albumin and plasma required to control the hemoconcentration are given in Table VIII. The blood specific gravity returned to normal levels, the left foot became warm and pink, the patient regained consciousness. At no time was there evidence of pulmonary edema or right sided cardiac embarrassment (no venous engorgement). The first urine specimen contained four plus albumin, red cells, and casts. As soon as consciousness began to appear, troublesome retching with vomiting of blood began. The patient was reported to have died later aboard the evacuating ship. (With the patient so severely burned and without treatment for so long and in such extreme shock, it was decided to cope with the hemoconcentration regardless of the volumes needed so long as venous congestion or pulmonary edema did not become evident, as this approach seemed to give him his best chance).

Later phase. This group includes burn cases seen after 72 hours when anemia and hypoproteinemia begin to be prominent.

CASE 8. This patient had sustained burns involving about 40 per cent of the body surface of second and third degree types 5 days before. Plasma had been administered, the amount was not known. On admission the blood-serum specific gravities were 1.047 to 1.019. Following 300 cubic centimeters of concentrated albumin solution (75 grams albumin), 500 cubic centimeters of normal plasma and 1,100 cubic centimeters of citrated blood during the first day the specific gravity values became 1.045 to 1.0215. An additional 1,100 cubic centimeters of citrated blood were given and progress was being made in correcting the anemia-hypoproteinemia complications when the patient was transferred for evacuation.

ANEMIA

An opportunity for the observation of specific gravity values in the anemia of malnutrition was afforded by a comparison of findings in a group of Javanese held by the Japanese as prisoners and utilized as laborers in Noemfoor

TABLE VIII.—SPECIFIC GRAVITY VALUES IN CASE 7

Time Hour	Blood Sp. gr.	Serum Sp. gr.	Hgb. cnart	Ser. prot. chart	Therapy	Remarks
0	1.074	1.028	22.7	7.2		
0.2	1.072	1.0265	21.8	6.7		
7					4,250 c.c. pl. 300 c.c. c.alb.	1 gm. Ca. gluconate
13					2,250 c.c. pl. 200 c.c. c.alb.	1 gm. Ca. gluconate
16					1000 c.c. D-H	
17.5					600 c.c. c.alb.	
19	1.059	1.0265	15.7	6.7		Improvement evident
21					1,750 c.c. pl.	
22	1.057	1.026	14.9	6.5		
22.5					1,000 c.c. D-H	
23						Transferred

Island (Geelvink Bay, New Guinea) and the findings on their captors, members of the Japanese Imperial Army (Table IX). The Javanese were a group of miserable looking individuals, markedly emaciated ("skin and bones" appearance), many too weak to walk; several displayed large tropical ulcers on the lower extremities. Through interpreters they gave the now stereotyped story of starvation in the midst of adequate food supplies and overwork impelled by brutal treatment. In

TABLE IX.—SPECIFIC GRAVITY VALUES IN ANEMIA OF MALNUTRITION

Subject	Blood Sp. gr.	Serum Sp. gr.	Hgb. chart	Hgb.* Sahli	Ser. prot. chart
Javanese prisoner	1.029	1.021	3.5	5.0	4.8
Javanese prisoner	1.0305	1.022	3.8	4.5	5.15
Javanese prisoner	1.031	1.021	4.4	5.4	4.8
Javanese prisoner	1.039	1.026	6.2	6.9	6.5
Javanese prisoner	1.032	1.023	4.1	5.4	5.47
Javanese prisoner	1.038	1.024	6.6	7.2	5.8
Japanese soldier	1.053	1.0255	13.1	14.5	6.3
Japanese soldier	1.056	1.026	14.4	14.7	6.5
Japanese soldier	1.057	1.0285	14.1	15.1	7.4
Japanese soldier	1.057	1.027	14.7	15.6	6.85
Japanese soldier	1.0575	1.029	14.3	15.7	7.55
Japanese soldier	1.059	1.029	15.0	16.4	7.55

*Artificial light as background.
Amounts of plasma given were too small to effect significant changes in serum protein levels.

the same location the Japanese were robust and well fed. In the captives, the specific gravity values were indicative of severe anemia and hypoproteinemia, while in the Japanese captors the values were within the normal range. A correlation with the Sahli hemoglobin values was also obtained. Blood and plasma infusions were given to some of these patients but the amounts were too small to alter appreciably the specific gravity values.

The treatment of anemia is demonstrated in a patient with malaria.

CASE 9. This person had not felt well for weeks and had been very ill for about 10 days prior to admission. An extraordinarily heavy infestation with plasmodium falciparum was noted on thick and thin blood smears. The patient was comatose and displayed a dry tongue and some loss of skin turgor. The dietary intake had been poor. The specific gravities (blood and serum) were 1.041 to 1.021, indicative of prominent anemia and hypoproteinemia. Following 1,000 cubic centimeters 5 per cent dextrose in saline, 1,000 cubic centimeters normal plasma, 1,000 cubic centimeters citrated blood (11.5 hours after admission) the specific gravity figures were 1.047 to 1.023. An additional 2,200 cubic centimeters of citrated blood and 1,000 cubic centimeters of normal plasma were given (20.5 hours after admission) and 16 hours later the specific gravities were 1.050 to 1.025. At 59 hours the values were 1.051 to 1.0245. The patient improved markedly. The transfusions seemed to be a definite adjuvant to the quinine and atabrine therapy in this case.

DEHYDRATION

If one considers that the clinical signs of dehydration (extracellular type with or without intracellular dehydration) are reliable then serious grades of dehydration have not been encountered as frequently in the wounded who have access to water as was expected. The clinical signs used include the urinary output and the specific gravity of the urine, dryness of the mouth and skin, thirst as expressed by the patient, loss of skin turgor and elevation of the specific gravity values of blood and serum. Of course, the majority of the patients seen had sustained wounds of the extremities with or without fractures and could and would take sufficient water by mouth. Abdominal cases (intestinal perforation, obstruction, colostomy, fistula cases) naturally presented more of a strict water-salt balance problem. One such case is presented.

CASE 10. This patient was seen 12 to 14 hours following the injury, shrapnel perforation of the abdomen. A loop of bowel and the surface of the urinary bladder had been injured. An emergency operation had been performed, the bladder repaired and the loop of intestine brought to the surface (marsupialized). The loop had broken down and produced a fistula.

On admission the patient exhibited signs of severe circulatory embarrassment (shock): coma with periods of restlessness, pulse very weak, blood pressure 90/60 millimeters hemoglobin, paleness, slight sweating, veins inconspicuous. The specific gravity values (blood—serum) were 1.058 to 1.0275, within the normal range. The shock was treated with citrated blood (2,600 c.c.) and normal saline (1,000 c.c.) by vein. There was definite clinical improvement, consciousness was regained, the blood pressure reached 100/72, the pulse was strong and regular but the patient had a ravenous thirst. There was loss of skin turgor, and the urinary output was negligible. At this time (7 hours after admission) the specific gravity figures were 1.063 to 1.028, an elevation of the blood value, which indicated a moderate concentration. One liter of 5 per cent dextrose in saline and 250 cubic centimeters of normal plasma lowered the specific gravity value of blood to 1.053 (19 hours after admission) but it returned to an elevated value (1.061 to 1.028 by 37 hours after admission). At this time 2,000 cubic centimeters of dextrose-saline and 500 cubic centimeters of normal plasma were given and the values again dropped to 1.057 to 1.0225 at 41 hours. After an additional 500 cubic centimeters of normal plasma the values were 1.054 to 1.025. The patient was much improved, quiet but continued to ask for large quantities of water. The bowel continued to discharge copious quantities of fluid. Additional saline and plasma (2,000 c.c. and 500 c.c.) were given to replace that lost through the fistulous opening. After transfer this patient was reported to have done well.

Intravenous protein feeding. When plasma solutions are administered by vein largely for the dietary value of the contained proteins, specific gravity values may be of use. Should the patient be receiving 1,000 to 2,000 cubic centimeters of normal plasma daily (60 to 120 grams proteins) and no significant alterations are noted in the concentration values from day to day, then one has a good idea that the administered solids and fluids are being utilized. A case in point was a patient with acute catarrhal jaundice and initial specific gravity values of 1.052 to 1.023. Eleven and one-half hours after 1,250 cubic centimeters of normal

plasma were given the values were 1.050 to 1.0255. An additional 1,250 cubic centimeters of normal plasma were given and later the specific gravities were 1.052 to 1.027.

EVALUATION OF STUDY

This study was begun by establishing normal values of whole venous blood and serum specific gravities for males of military age at sea level in a tropical climate. Then the ranges, means, and standard deviations were obtained. Significance was given to values outside of the range obtained by the mean $\pm 2\sigma$.

A comparison of the blood specific gravity values, the hemoglobin concentration as measured by Sahli's method and the red blood cell count gave a correlation similar to that obtained by Ashworth and Adams (1). Alterations in the specific gravity values as produced by various solutions given by vein gave results similar to results in other studies (2, 9, 10, 11).

Illustrations of the copper sulfate procedure as applied to the care of various types of abnormalities seen in battle casualties were presented. These concentration studies (specific gravity of blood and serum) were of great value in demonstrating trends in the make-up of the circulating blood (hemodilution, hemoconcentration, anemia, hypoproteinemia, etc.), and to a great extent in demonstrating the severity of trends. In conjunction with the clinical picture (history, physical examination, etc.), the blood pressure level and the response to therapy, they formed a valuable asset in the appraisal and therapy of the wounded.

CONCLUSION

The copper sulfate method for determining the specific gravities of blood and serum can be used to great advantage in the appraisal and treatment of various surgical conditions. Additional evidence supporting this conclusion has been presented. The method is of particular value in military use when several factors, as the sudden arrival of large numbers of wounded men, the necessity of rapid decisions concerning the shock state, the appraisal of patients before anesthesia and operative procedures are instituted, the need for medical judgment during attacks by the enemy, make its simplicity, speed, degree of accuracy and instant applicability most desirous.

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LUMBAR APPENDICITIS AND LUMBAR APPENDECTOMY

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A SOMEWHAT rare form of appendicitis, which may be mistaken for other conditions unless the symptoms are definitely understood, has not, to my present knowledge, been clearly described. It is a type in which the appendix is posterior and lies against the peritoneum dorsal to or below the cecum. The general peritoneal cavity is not involved and the characteristic abdominal symptoms of appendicitis are absent. Without gross perforation and usually without intra-abdominal pus formation, bacteria from the appendix penetrate the thin peritoneal layer and spread in the loose extraperitoneal connective tissue of the loin and pelvis, producing first a watery edema like that often seen in the deep tissues of the anterior abdominal wall from appendicitis, but with a much greater tendency to a spreading, purulent, and necrotic process. The tela subserosa or extraperitoneal connective tissue of the posterior abdominal wall and pelvis is much more abundant, is looser, contains more fat, and is less resistant to infection than that of the anterior abdominal wall. There results from the lower involvement of the right extraperitoneal space a pelvic abscess, and from the upper type a right perinephritic abscess. Coincidentally, inflammatory products within the appendix usually discharge into the cecum and the appendix undergoes resolution.

I have long believed that appendicitis without intra-abdominal suppuration is a common cause of the so-called idiopathic perinephritic abscess. This concept, however, apparently has received little attention from urologists, although Hugh Young mentions appendiceal abscess as a possible cause of perinephritic abscess.

If an anterior abdominal incision is made in the early stages of lumbar appendicitis, with removal of the appendix, the operator may encounter nothing to direct his attention to the retroperitoneal inflammation. The peritoneum over the lumbar area is not necrotic or perforated and, in the limited area not covered by the cecum, shows no greater inflammatory change than that usually found contiguous to an inflamed appendix. If careful palpation were made a cushion-like elevation of the peritoneum dorsal to the appendix might be detected, but I dare say few operators have considered such examination necessary. With the lower type, a large *extraperitoneal* pelvic abscess which later forms may be mistaken for and drained as a localized *intraperitoneal* collection. Likewise, the operator will overlook the primary appendicitis when, without opening the peritoneum, he drains only the secondary retroperitoneal or perinephritic abscess. Apparently the septic extension through the peritoneum is uncommon if the appendicitis leads to a plastic or purulent peritoneal exudate. In other words, the extraperitoneal extension rarely is associated with a gangrenous or perforated appendix.

The signs and symptoms of the lower type of lumbar appendicitis are striking and, when fully developed, very characteristic. The attack may start, as in the usual case of appendicitis, with epigastric distress, nausea, moderate fever, elevation of the pulse rate, and polymorphonuclear leucocytosis. The pain, tenderness, and rigidity, however, do not localize at McBurney's point but rather in the right lumbar muscles above the crest of the ilium. Medial to the right anterior superior spine of the ilium the signs of appendicitis, such as local tenderness, muscular rigidity, and the iliopsoas and obturator tests, may be entirely absent. The patient, however, may complain of pain and tenderness over the anterior surface of the right thigh, of the right scrotum or, in the female, of the right labium majus. In the inflamed extraperitoneal connective tissue back of the cecum lie the genitofemoral nerve, the external spermatic branch of which innervates the cremaster and scrotal or labial skin, and the lum-

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boinguinal branch, supplying the skin of the upper anterior thigh. From involvement of the lateral femoral cutaneous and the femoral and obturator nerves, symptoms referred to the lateral surface of the thigh, lower anterior surface or medial surface of the thigh, or knee also, may be produced. As the ureter runs through the intensely inflamed connective tissue, ureteral colic and hematuria may be present. The characteristic syndrome of lumbar appendicitis is lumbar pain, tenderness, and muscular tension associated with pain in the anterior right thigh, testicle, or labium to which may be added vesical irritability and hematuria. A degree of lumbar scoliosis with concavity to the right may develop, and later, from the inflammatory exudate, the margins of the right psoas muscle may appear blurred or the muscle shadow obliterated on roentgen examination.

The pathological changes can be appreciated only by an incision exposing the extraperitoneal connective tissue in the right lumbar and iliac regions together with the appendix.

In operating an oblique incision is made above the crest of the right ilium, along the fibers of the external oblique which are separated and partly divided. The retroperitoneal connective tissue space is entered and evacuated of the inflammatory exudate, and wiped dry. The peritoneum is opened by a small incision behind or below the cecum through which the appendix is delivered. The mesoappendix is clamped and divided in sections, and the base of the appendix doubly ligated and divided by a cautery between the clamps and beyond the ligatures. The mesoappendix is ligated over the stump of appendix in sections with one of the ligatures. As a rule, the opening in the peritoneum may be closed with 36 gauge alloy steel wire and the septic retroperitoneal space drained, the wound being closed about the drain with layer sutures of No. 32 wire. The retrocecal appendix lies against the peritoneum and is accessible from the loin.

The following is the report of a typical case of lumbar appendicitis:

Mr. H. B., 22 years of age, a medical student, became ill in the afternoon, with generalized dull aching abdominal pain after eating "Chinese food." At 6 o'clock the following morning he had a severe chill, was nauseated and vomited, and at 10:00 a.m. he entered the accident dispensary of Temple University Hospital with the diagnosis of a right urinary tract calculus as it was thought that the urine contained blood. At this time the hemoglobin was 13.5 (79.9 per cent); erythrocytes 5,030,000; color index 80; leucocytes 13,800; polymorphonuclears 82, lymphocytes 13, monocytes 3, eosinophiles 1, nonfilaments 51, filaments 31; urine: clear, no sediment, acid, cloud of albumin, much amorphous material; blood urea nitrogen 45 milligrams; plasma carbon dioxide, 0.50. The abdominal ache disappeared and there were several diarrheal movements. (A month previously he had had a transient acute abdominal attack with nausea, vomiting, and constipation.)

In the afternoon he was transferred from the accident dispensary to the hospital, with the impression that he had an acute gastroduodenitis and possible stone in the right kidney or ureter. His temperature then was 103.3; pulse 86; respiration 22; leucocytes 26,000; polymorphonuclears 89; nonfilaments 78; filaments 11; blood urea nitrogen 60 milligrams; urine: 1.028, no casts or blood cells, occasional leucocytes.

The patient, a well developed and heavily muscled young man, was seen in consultation about 4:00 p.m. He then was complaining of pain and sensitiveness in the lower right loin, the anterior right thigh and in the right testicle. There was no abdominal distention, muscle resistance, or tenderness. Posterior to the line of the right anterior iliac spine and above the crest of the right ilium was a painful area with marked tenderness and increased muscular tension. With a diagnosis of retrocecal appendicitis and secondary lumbar phlegmon, operation was performed about 4:30 that afternoon.

An oblique, 9 centimeter skin incision was made about 2 centimeters above the right iliac crest. The fibers of the external oblique muscle were separated and the lumbar fascia and subperitoneal connective tissue (which were greenish, seminecrotic, malodorous, and contained 60 to 90 c.c. of pus) were exposed. The area was mopped out, and a 3 centimeter incision made through the peritoneum under the cecum, exposing the appendix, which was swollen, injected, and very lightly attached to the peritoneum but without perforation or plastic exudate. The peritoneal surface was moist from a very small amount of turbid odorless fluid. The base of the appendix was doubly ligated with No. 32 alloy steel wire, divided by cautery, the mesoappendix ligated over the stump with one of the ligatures, and the peritoneal opening closed with fine wire sutures. The wound was lightly united with interrupted wire sutures around a drain extending extraperitoneally from the pelvis.

Pathologic report. The appendix measured 5 by 1 centimeter and was not perforated. The serosa was thickened and injected, the lumen narrowed, but not obliterated. The mucosa was infiltrated by plasmo-

cytes, lymphocytes, eosinophiles and neutrophiles, the epithelium lacking in many places and the glands replaced by fibrous connective tissue containing inflammatory cells. The picture was that of a healing acute appendicitis with evidence of a previous inflammatory attack. The day following operation the urine contained a few red cells and leucocytes.

The patient had an uninterrupted recovery and was discharged from the hospital 15 days after the operation.

SUMMARY

A type of appendicitis is described in which the inflamed organ has a posterior or retrocecal position, and from which the infection spreads through the thin contiguous peritoneal layer with little abdominal reaction and produces a spreading phlegmon or abscess in the poorly resisting, loose areolar tissue of the retroperitoneal space in the right lumbar and pelvic areas. As the signs and symptoms are predominantly in the right lumbar region, I have termed the condition "lumbar appendicitis." The appendicitis tends to subside spontaneously, probably largely by discharge of inflammatory products through the open lumen of the appendix into the cecum, and is associated with so few characteristic symptoms as to be overshadowed in the later development of a perinephritic or pelvic abscess. In those cases in which the appendiceal symptoms are more definite, the retroperitoneal extension may be diagnosed and drained through the abdomen as a localized intraperitoneal collection.

The initial symptoms of lumbar appendicitis usually are abdominal colic, nausea and fever, soon followed by pain, tenderness, and muscular rigidity in the loin, but with a degree of fever and possibly a chill unusual in acute appendicitis. This condition is to be attributed to the greater toxic absorption from the retroperitoneal space than from the peritoneum. Especially characteristic are symptoms due to the irritation of structures surrounded by the inflamed extraperitoneal connective tissue, as the right genitofemoral, lateral femoral cutaneous, femoral and obturator nerves, and the ureter. The syndrome of pain, tenderness, and rigidity in the lower right loin, with pain and tenderness referred to the right testicle and anterior part of the right thigh, occurring after a brief abdominal attack, is quite diagnostic.

In treatment it is important that the appendix be removed and the phlegmon drained through a lumbar or retroperitoneal approach; otherwise the surgeon may remove an inflamed appendix and overlook the retroperitoneal phlegmon, or drain the pelvic or perirenal abscess and overlook the appendix. With removal of the appendix the peritoneum may be closed, or drained with the lumbar-pelvic space through a single lumbar incision.

CORRECTION OF BLOOD LOSS DURING SURGICAL OPERATIONS

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THE study of blood changes produced by hemorrhage has received much attention in the past. Considerably less is known about the changes produced in the circulating blood by various types of anesthesia, the intravenous injection of fluids, and the various exigencies of major surgical operations. These variables are so numerous that systemic consequences of traumatizing operations are not reflected in the circulating blood, and the determinations of hematocrit, hemoglobin, or plasma proteins give little information as to the quantity of blood lost or of pending shock. Support for this statement is found in a brief review of the literature and in the analysis of the blood changes of 35 patients undergoing major surgical operations to be presented.

Dyson, Plaut, and Vaughan observed the reactions to changes in the blood volume resulting from the removal of 540 milliliters of blood from 8 healthy donors in whom many of the variables were reduced to a minimum. They noted that in only one instance the change in blood volume as determined by the dye method was found to correspond to the calculated value. In the others, dilution or overdilution was associated with an increase in mean corpuscular volume, suggesting that some of the fluid replacing the blood lost was absorbed by the red cells. The authors also point out that blood loss may occur without affecting the hemoglobin level.

A rarely considered variable in the normal individual undergoing blood loss is the uncertain amount of blood expressed from the spleen. According to Lewis, Werle, and Wiggers, the spleen contracts vigorously during hemorrhage, and may shrink to a volume of 50 per cent or less of its original size. Wu, in 1943, found the capacity of 20 spleens to vary from 60 to 400 milliliters, a volume which may be added to the blood volume during hemorrhage.

Thus it is evident that, even in simple uncomplicated hemorrhage in relatively normal individuals, variable factors contribute to make changes in hemoglobin, plasma proteins, and hematocrit unpredictable. To these factors must be added the inherent differences present in each surgically sick patient and the various methods used in treatment. In general, surgical operations, anesthesia, shock, varying degrees of dehydration and malnutrition, fever, anemia, hypoproteinemia,and intravenous infusions of crystalloids, plasma and variable whole blood, all contribute to changes in the circulating blood.

Windfeld, in 1937, made direct measurements of blood lost during operations and demonstrated that determinations of hemoglobin concentrations before and after operation failed to give quantitative information regarding the amount of blood lost.

Stewart and Rourke, recording the changes in the volumes of blood and interstitial fluid during operations under ether anesthesia, stressed the fallacy of assuming a quantitative relationship between changes in concentration of hemoglobin or plasma proteins and changes in plasma volume. From their observations, reduction in plasma volume may be greater than can be accounted for by hemorrhage.

Ariel, Pack, and Rhoads compared liver biopsy specimens secured at the beginning and the end of gastric operations and found that hepatic cells usually swell during surgery. The average increase in total liver water was 1.1 per cent. By inference, the red blood cells also may take up some of the fluid transferred from the interstitial space to the blood stream.

In March, 1945, Evans published conclusions resulting from the recent studies of three

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TABLE I.—BLOOD LOSS AND CHANGES IN HEMATOCRIT, HEMOGLOBIN, AND PLASMA PROTEINS IN OPERATIONS ON THE THYROID

Patient number	Age and sex	Weight kgm.	Duration, min.	Hypotension	Fluids, ml.			Blood loss			Hematocrit volume per cent	Hemoglobin gm. per cent	Plasma proteins gm. per cent
					5 per cent Glucose	Saline	Blood	ml.	Per cent total blood volume	Per cent corrected	Percentile change, postoperative determination	Percentile change, postoperative determination	Percentile change, postoperative determination
2	53–F	43	110*	0	1400	0	0	234	− 8.3	− 8.3	34.5 − 0.9	12.1 − 3.3	6.40 − 2.4
3	14–M	47	58*	0	0	0	0	276	− 7.5	− 7.5	48.4 −10.1	15.6 −10.3	7.28 −7.6
9	44–F	68	140*	0	1000	0	0	409	− 9.1	− 9.1	41.6 − 7.0	11.6 − 2.6	7.35 −1.0
10	51–F	55	93*	0	1000	0	0	204	− 5.3	− 5.3	46.2 − 6.1	14.8 − 6.8	6.70 − 7.2
15	58–M	84	121*	0	1000	0	0	389	− 6.0	− 6.0	54.4 − 5.9	12.7 0.0	7.38 0.0
16a	15–F	39	102†	0	1000	0	0	725	−27.8	−27.8	41.4 0.0	13.1 − 3.1	7.14 0.0
16b	15–F	39	110†	0	1000	0	0	688	−26.4	−26.4	39.3 − 1.0	12.4 − 5.6	6.53 −3.2
Average percentile change										−10.7	− 5.0	− 4.4	−3.0

*Tribromoethanol, nitrous oxide and ether.
†Tribromoethanol, nitrous oxide, local procaine.

separate shock research groups (of New York, of Atlanta, and of Richmond) in which estimations of blood volume were made by means of the dye method. He presented simple reasons why the determination of hemoglobin and plasma proteins does not suffice in estimating the blood volume in surgical patients. He pointed out that "in whole blood loss, almost equal quantities of red cells and of plasma are missing, so that hemoglobin and plasma protein concentrations will be relatively unchanged, and the surgeon is given a false sense of security. In situations when moderate quantities of red blood cells and much plasma are lost, there will be hemoconcentration, yet there is no indication of red cell loss. Only in situations of relatively simple plasma loss (such as peritonitis and some burns) will hemoglobin and hematocrit give an accurate picture of the trend of blood volume alterations."

Introduction of intravenous fluids further complicates the picture. Although Bogert, Underhill, and Mendel found, in 1916, that the blood volume of rabbits injected intravenously with saline returned to normal 30 minutes after the injection, later investigations have shown that alterations in blood volume following intravenous infusions last much longer. Gilligan, Altschule, and Volk found that the blood volume increases after intravenous fluids may not return to the normal level for 2 hours.

The blood at the end of operation is thus the resultant of these variable influences, and it becomes impossible to select any one chemical determination indicative of the condition of the postoperative patient, unless it is the determination of the plasma volume, a laborious and often unsatisfactory procedure in the seriously ill patient.

In support of this statement, the data compiled from the determinations of hematocrit, hemoglobin, and plasma proteins of 35 patients before and after major surgical operations are presented in Tables I through VI. In each instance the preoperative value is recorded and below it the percentile change from the preoperative value obtained at the end of operation. The blood lost at operation was determined and has been reported elsewhere (4). Heparinized blood was used, and a 2 milliliter sample sufficed for the 3 determinations. Hematocrit was measured in sealed, capillary tubes spun until no further change in cell volume occurred. Hemoglobin was analyzed as oxyhemoglobin by the photoelectric method of Evelyn on 20 cubic milli-

TABLE II.—BLOOD LOSS AND CHANGES IN HEMATOCRIT, HEMOGLOBIN, AND PLASMA PROTEINS IN MASTECTOMY

Patient number	Age and sex	Weight kgm.	Duration, min.	Hypotension	Fluids, ml.			Blood loss			Hematocrit volume per cent	Hemoglobin gm. per cent	Plasma proteins gm. per cent
					5 per cent Glucose	Saline	Blood	ml.	Per cent total blood volume	Per cent corrected	Percentile change, postoperative determination	Percentile change, postoperative determination	Percentile change, postoperative determination
1	59–F	97.7	147*	+	1000	0	0	827	−12.8	−12.8	43.3 − 2.3	15.0 −15.3	7.21 −6.7
25	61–F	64.0	143*	0	1000	100	250	670	−15.8	− 8.7	43.9 − 5.0	13.6 − 5.1	7.04 −2.6
27	61–F	85.9	249*	++	1200	200	450	924	−17.8	− 8.3	47.2 − 5.5	15.6 −14.7	7.25 −8.1
29	34–F	55.0	168*	0	1200	0	0	529	−14.6	−14.6	42.3 −11.1	13.2 −18.9	7.86 −17.3
40	55–F	63.9	215*	0	1000	125	275	1091	−25.8	−19.4	45.7 − 2.0	13.3 −11.3	8.24 −6.3
Average percentile change									−17.4	−12.8	− 5.2	−13.1	−8.2

*Nitrous oxide, oxygen and ether.

meters of well mixed blood, measured in the falling drop pipet with the aid of a Guthrie pipet holder. This procedure was adopted to avoid the inaccuracies of the 20 cubic millimeter blood pipet. Plasma proteins were determined by the method of Barbour and Hamilton and by the use of Weech's formula. Hemolyzed plasmas were corrected for hemoglobin by an adaptation of Evelyn's method before the plasma proteins were calculated from the plasma specific gravity.

Table I is concerned with the changes occurring during thyroidectomies. In this group only 1 patient received no intravenous fluid. This patient (3) lost 227 milliliters of blood or 7.5 per cent of his total blood volume.[1] A comparison of the percentile changes of both hematocrit and hemoglobin (−10.1 per cent and −10.3 per cent, respectively) and the calculated blood loss (7.5 per cent) indicates an overdilution, similar to the reaction of healthy donors to the withdrawal of blood.[1]

All the other patients in Table I received 5 per cent glucose intravenously during the operation. Patient 10 with a blood loss of 204 milliliters or 5.3 per cent showed little or no tendency to hemodilution above that of the blood lost, in spite of 1000 milliliters of glucose infused during the operation. In other words, approximately 750 milliliters of fluid have left the blood stream during the operation.

[1]Total blood volume was calculated from the average values determined by Gibson and Evans, 77.7 milliliters per kilogram of body weight in the male and 66.1 milliliters per kilogram in the female.

In contrast, patient 15 showed changes in hematocrit (−5.9 per cent) comparable to the blood loss (−6.0 per cent), but both hemoglobin and plasma proteins remained unchanged. This instance suggests an absence of hemodilution, and even a shrinkage of the red cells.

Patient 16 was operated on for a very large, toxic goiter. In spite of the large blood loss of 725 milliliters, 28 per cent of the total blood volume, and the infusion of 1000 milliliters of glucose, there was no evidence of hemodilution. Later patient 16b during the second stage of the hemithyroidectomy, showed a similar reaction. These findings suggest the rapid disappearance of the intravenous fluid and the absence of hemodilution after large losses of blood.

Table II presents the results of studies during radical mastectomies. Patient 1 received 1000 milliliters of glucose during the operation, which involved a blood loss of 821 milliliters or 12.8 per cent of the total blood volume. She developed mild hypotension. The percentile change in hemoglobin (−15.3 per cent) corresponded to the blood loss (−12.8 per cent). The hematocrit change (−2.3 per cent) is rather indicative of increase in mean corpuscular volume.

In patient 29, with a loss of 14.6 per cent of the total blood volume, the change in hemoglobin (−18.9 per cent) and in plasma proteins (−17.3 per cent) corresponds to the blood loss, with a tendency toward overdilution, while

TABLE III.—BLOOD LOSS AND CHANGES IN HEMATOCRIT, HEMOGLOBIN, AND PLASMA PROTEINS DURING COMBINED ABDOMINOPERINEAL RESECTIONS

Patient number	Age and sex	Weight kgm.	Duration, min.	Hypotension	Fluids, ml.			Blood loss			Hematocrit volume per cent	Hemoglobin gm. per cent	Plasma proteins gm. per cent
					5 per cent Glucose	Saline	Blood	ml.	Per cent total blood volume	Per cent corrected	Percentile change, postoperative determination	Percentile change, postoperative determination	Percentile change, postoperative determination
7	69–M	58.1	107*	++	1200	0	0	183	− 4.1	− 4.1	38.4 +10.7	15.9 −17.6	7.32 −1.1
13	55–F	68.2	180*	0	2000	0	0	410	− 9.0	− 9.0	46.7 −12.4	14.6 −19.2	6.94 −18.5
17	68–M	58.2	145*	0	600	400	450	523	−11.6	− 1.9	42.8 − 5.6	13.2 0.0	7.11 −4.4
18	61–F	58.1	185*	0	900	300	450	519	−13.5	− 1.8	41.3 − 1.7	13.3 − 5.3	6.63 −6.9
23	49–M	48.9	200*	+	1000	0	450	474	−13.3	− 0.8	39.8 −10.8	12.2 − 3.3	6.56 −2.4
24	70–M	57.1	235+	+	1000	200	300	686	−15.5	−10.3	47.2 − 0.8	14.2 − 6.3	7.48 −6.8
26	60–F	52.7	110*	+++	1000	100	235	247	− 7.1	− 0.3	47.8 − 8.0	15.2 − 8.2	7.32 −3.8
30	48–F	71.8	245†	0	1000	0	0	494	−10.4	−10.4	37.6 −13.8	10.7 −14.0	7.68 −14.1
34	73–M	57.3	156†	+	900	150	400	255	− 5.5	+ 4.1	47.1 − 6.2	14.7 − 6.8	6.60 −3.6
36	54–F	62.7	85*	0	1000	0	450	483	−11.6	− 0.8	39.8 − 5.5	11.3 − 4.4	6.76 −1.5
38	75–M	76.9	185†	+	700	400	390	375	− 6.3	+ 0.3	39.0 + 3.9	10.8 + 1.6	6.80 −9.0
42	48–M	64.0	160†	+	1300	75	125	306	− 6.1	− 3.7	47.7 −10.7	15.0 −12.9	6.46 ?
Average percentile change										− 3.2	− 5.1	− 8.0	−6.6

*Continuous spinal, procaine
†Spinal, nupercaine

the hematocrit (−11.1 per cent) is indicative of cellular swelling.

In these mastectomies the changes in hemoglobin compared more closely with the blood loss than did the changes in hematocrit or plasma proteins. However, even the hemoglobin changes are often misleading. Blood losses were large, averaging 800 milliliters and hypotension occurred frequently.

Patients undergoing combined abdominoperineal resection for carcinoma of the rectum are represented in Table III. Here the average changes in hematocrit (−5.1 per cent), hemoglobin (−8.0 per cent) and plasma proteins (−6.6 per cent) correspond fairly well with average blood loss (−3.2 per cent), but suggest a tendency toward overdilution. Individually, this ideal correlation exists in only one instance, patient 30. The other cases show considerable variation. For example, patient 7 sustained a blood loss of 183 milliliters (4.1 per cent) of the total blood volume. This patient's reaction to the small loss of blood was a change in hematocrit of +10.7 per cent, in hemoglobin of −17.6 per cent and in plasma proteins of −1.1 per cent. A fairly pronounced hypotension may have been responsible for some of these shifts.

Difficult and prolonged surgery for diseases of the biliary tract provided the cases in Table IV. In these patients hypotension is frequently a prominent part of the surgical picture. In spite of the existing, marked hypotension, patient 28 presents blood changes comparable to the hemodilution resulting from a blood loss of 8.1 per cent. On the other hand, patient 21, after a corrected blood loss of 14.4 per cent (total loss less transfusion during operation), showed a hematocrit change of −4.5 per cent, a hemoglobin change of +1.5 per cent, and a plasma protein change of −11.1 per cent.

TABLE IV.—BLOOD LOSS AND CHANGES IN HEMATOCRIT, HEMOGLOBIN, AND PLASMA PROTEINS DURING SECONDARY AND PLASTIC OPERATIONS ON THE BILIARY TRACT

Patient number	Age and sex	Weight kgm.	Duration, min.	Hypotension	Fluids, ml.			Blood loss			Hematocrit volume per cent	Hemoglobin gm. per cent	Plasma proteins gm. per cent
					5 per cent Glucose	Saline	Blood	ml.	Per cent total blood volume	Per cent corrected	Percentile change, postoperative determination	Percentile change, postoperative determination	Percentile change, postoperative determination
11	50–F	61.0	105*	0	1000	0	0	158	− 3.9	− 3.9	46.6 − 3.2	15.9 −12.6	7.58 −12.9
14	54–M	50.3	220*	+	600	160	340	412	−10.5	− 2.2	43.1 +14.6	14.3 + 2.1	7.42 + 8.2
21	51–M	74.6	255*	++	1200	375	625	1455	−27.5	−14.4	40.4 − 4.5	13.6 + 1.5	6.40 −11.1
22	50–M	81.0	113*	0	1000	100	270	242	− 3.8	− 0.4	52.9 + 0.8	16.6 + 3.6	7.28 + 1.9
28	68–M	65.0	185*	++	1000	0	0	406	− 8.1	− 8.1	50.5 − 4.8	15.6 − 7.1	7.89 − 6.0
32	51–F	72.1	160*	0	2000	0	0	287	− 6.0	− 6.0	44.5 + 5.6	14.0 − 7.9	7.28 + 1.4
39	34–F	41.8	180*	0	500	125	280	454	−16.4	− 6.5	40.3 + 9.2	13.0 − 2.9	7.93 − 5.2
41	51–F	39.3	130*	++++	250	250	480	1065	−41.0	−22.6	44.0 − 5.7	14.6 −14.9	7.45 −10.1
Average percentile change: biliary tract										− 8.0	+ 1.5	− 4.8	− 4.2

*Nitrous oxide, oxygen and ether

TABLE V.—BLOOD LOSS AND CHANGES IN HEMATOCRIT, HEMOGLOBIN, AND PLASMA PROTEINS, DURING OPERATIONS FOR COMPLICATED GASTRIC LESIONS

Patient number	Age and sex	Weight kgm.	Duration, min.	Hypotension	Fluids, ml.			Blood loss			Hematocrit volume per cent	Hemoglobin gm. per cent	Plasma proteins gm. per cent
					5 per cent Glucose	Saline	Blood	ml.	Per cent total blood volume	Per cent corrected	Percentile change, postoperative determination	Percentile change, postoperative determination	Percentile change, postoperative determination
6	62–F	59.6	287*	+++	3000	0	0	552	−14.0	−14.0	40.5 +12.4	13.7 − 1.5	6.60 +13.3
8	65–M	51.8	270*	0	300	700	900	804	−20.0	+ 2.4	41.2 + 8.3	13.7 + 4.4	5.99 + 1.7
31	59–M	60.9	155*	0	1000	0	0	321	− 6.8	− 6.8	47.3 + 0.5	13.7 0.0	6.46 + 7.7
Average percentile change: gastric lesions										− 6.1	+ 7.1	+ 1.0	+ 7.6

*Nitrous oxide, oxygen and ether.

TABLE VI.—SUMMARY

Operation	Number cases	Average blood loss			Average percentile change		
		ml.	Per cent	Per cent*	Hematocrit	Hemoglobin	Plasma protein
1. Thyroidectomy	6	373	−10.7	−10.7	−5.0	− 4.4	−3.0
2. Radical mastectomy	5	808	−17.4	−12.8	−5.2	−13.1	−8.2
3. Combined abdominoperineal resection	12	410	− 9.5	− 3.2	−5.1	− 8.0	−6.6
4. Biliary tract	8	594	−14.6	− 8.0	+1.5	− 4.8	−4.2
5. Gastric lesions	3	599	−13.6	− 6.1	+7.1	+ 1.0	+7.6

*After replacement of blood during the operation.

As mentioned before, Pack and associates (1) demonstrated swelling of liver cells in patients following operation on the stomach. The cases presented in Table V show evidence of swelling of red blood cells as shown by the increased hematocrit.

Table VI summarizes the average blood losses and the average changes in hematocrit, hemoglobin, and plasma proteins. Blood losses calculated from the changes in hematocrit, hemoglobin, or plasma proteins would lead to an underestimation of the need for replacement in mastectomies, thyroidectomies, biliary tract surgery, and gastric lesions. In combined abdominoperineal resections, the individual estimates would also be uncertain in spite of the fact that the average values shown in the series correspond fairly well to the blood lost.

COMMENT

Thus, an analysis of the findings in the 35 cases here presented furnishes further evidence that no easy practicable laboratory procedure will indicate the status of the circulating blood in the postoperative patient.

Studies of blood loss invariably show that the loss is almost always greater than the surgeon estimates. It is becoming widely recognized that the only wholly suitable replacement for operative blood loss is whole blood and that the greatest benefits result when the blood is given as the loss occurs.

The surgeon, therefore, should plan in advance for the adequate replacement of the deficiency caused by bleeding during the operation. To do this, he must usually rely upon his own knowledge of the amount of blood loss to be expected in each case. Recognizing this fact, the present authors, in a previous publication (4), tabulated the average blood losses occurring during the usual types of operations as calculated from 626 cases reported in the literature.

CONCLUSIONS

Whole blood is required adequately to replace blood lost during surgical operations. The replacement is most effective when whole blood is given as the loss occurs.

The amount of blood needed in each surgical case can seldom be determined directly. Hemoglobin, hematocrit, and plasma protein concentrations fail as an accurate measure of this need. Plasma volume determinations are more accurate, but are too laborious and time consuming for routine use.

A knowledge of blood loss during operation as available in the literature offers a practical basis for planned transfusions during operation.

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PATELLECTOMY IN THE MILITARY SERVICE

A Report of 19 Cases

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THE subject of patellectomy, or complete excision of the patella, has long been a controversial one. Those opposing the procedure argue that if the patient regains complete flexion of the knee, there is resulting limitation of extension, and conversely, if he has complete extension, he cannot fully flex the knee (Fig. 1a, b).

We believe that patellectomy can be a very successful operation, and that patients with complete patellectomy can have normal knee function. Many operations have been devised for this procedure, each claiming some special advantage. We carry no banner for any particular operation, but believe only that the essential aim should be to eliminate the slack in the quadriceps tendon which is created when the patella is removed.

The amount of slack to be eliminated has not been adequately defined in the literature. Consequently we have herein attempted to clarify the subject on a mathematical basis, although realizing that the figures used are averages and do not apply to any given case. For purposes of the computations we have accepted 2 centimeters as the average thickness, and 5 centimeters as the average length of the patella, and we have further assumed that the quadriceps tendon drops the entire 2 centimeters when the patella is removed (which is not entirely true in view of the thickness of the quadriceps tendon itself). We have computed that this portion of the quadriceps tendon becomes lengthened to about 6.4 centimeters, or a gain of about 1.4 centimeters.

Since muscle power is directly related to the length of the individual fibers and hence to overall contractile length, it can be readily seen that a gain in length of 1½ centimeters would be disastrous to function, both in strength of the quadriceps and in range of extension of the knee. This point has not been adequately clarified and for this reason we insist that the elimination of the slack is the important principle in the operation and that it makes little difference whether the patella is reached through a transverse, parapatellar, or other approach.

The operation we have used is as follows (Fig. 2): The patella is approached through a short median parapatellar incision. A straight longitudinal incision is made through the quadriceps expansion in the midline of the

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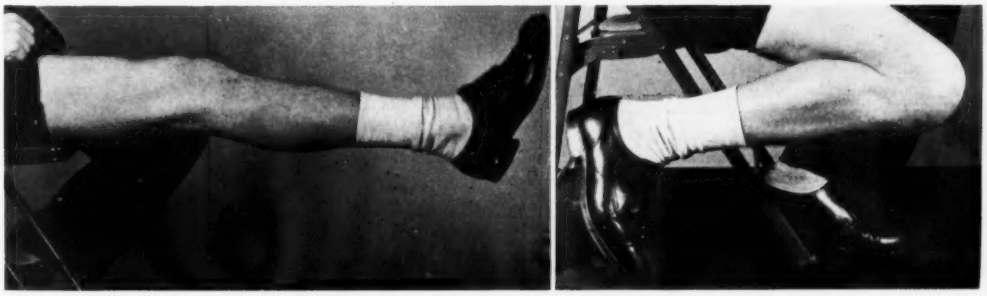

Fig. 1. Patient A.L., aged 24 years. Chondromalacia patellae of right knee. a and b, Photographs made 8 weeks after operation demonstrate restoration of full range of extension and flexion.

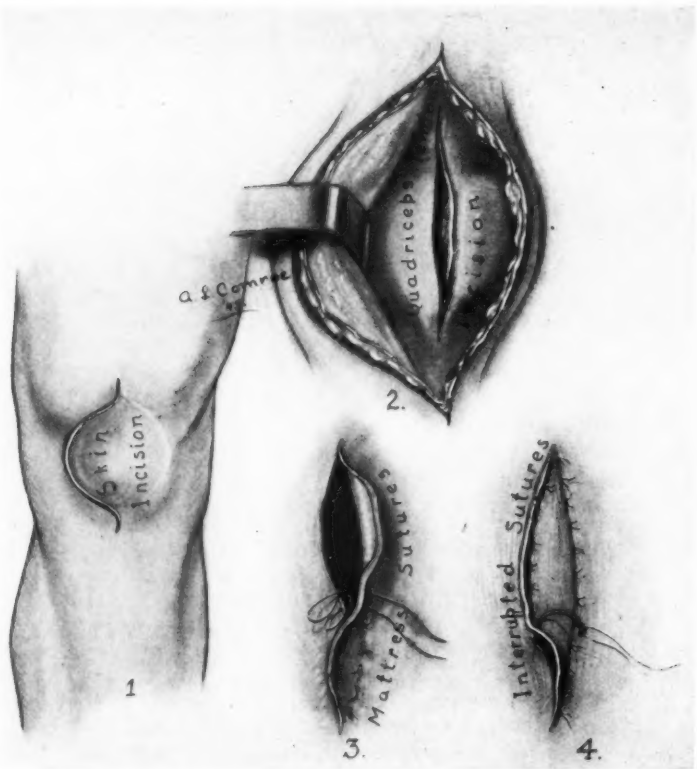

Fig. 2. Incisions and method of lateral plication. 1, Median parapatellar skin incision. 2, Longitudinal incision of quadriceps tendon in midline of patella. Patella partially exposed with beginning undermining of tendon anteriorly. 3 and 4, Patella excised. Lateral plication performed with knee in full extension, by use of No. 00 black silk mattress sutures.

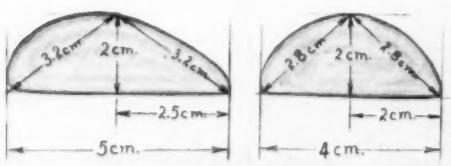

Fig. 3. a, left, The arc is assumed to equal its chord. Application of Pythagorean theorem shows chord to equal the square root of 10.25 or 3.2, and the length of the quadriceps tendon then is 6.4 centimeters, or 1.4 centimeters longer than the patella. b, The same assumptions apply, the chord in this case being 2.8 and the width of the quadriceps tendon then is 5.6 centimeters or 1.6 centimeters wider than the patella. It is to be noted that the figure for longitudinal slack—1.4 centimeters—bears no relation to the figure for lateral plication, 1.6 centimeters.

patella, extending 1 centimeter above and below the limits of the bone. The expansion is then removed by sharp dissection, left as intact as possible, and the patella is removed after cutting through the synovial attachments. The quadriceps tendon is then plicated laterally a distance of 1.6 centimeters at the midpoint, and tapering toward both ends. This figure is arrived at as before, by assuming the thickness of the patella as 2 centimeters, the width as 4 centimeters, and the slack to be eliminated being computed as 1.6 centimeters (Fig. 3). In actual practice, if one merely plicates all the available tissue in the lateral direction without tension, the result will be the same. However, this plica-

TABLE I.—CLINICAL RÉSUMÉ OF 19 CASES OF PATELLECTOMY

Patient	Age years	Injury	Infection	Duration symptoms preoperative	Postoperative period evaluated up to July 25, 1945	Function		Symptoms	
						Preoperative	Postoperative	Preoperative	Post-operative
1	29	Fracture comp. commin.	No	8 mos.	5 mos.	Normal	Normal	Pain, swelling	No
2	23	Fracture comp. commin.	6 wks.	6 mos.	6 mos.	180–110	180– 90	Pain, swelling	No
3	22	Fracture comp. commin.	No	5½ mos.	3 mos.	170– 90	180– 90	Marked pain, swelling	No
4	29	Fracture comp. commin.	No	9 mos.	2½ wks.	180–100	180– 90	Pain, grating	No
5	22	Fracture comp. commin.	No	5 mos.	6 mos.	170–160	180– 95	Pain	No
6	22	Fracture comp. commin.	No	7 mos.	4 wks.	180–110	180– 90	Pain, grating	No
7	34	Fracture comp. commin.	7 wks.	4½ mos.	4 wks.	180–155	180–100	Pain, grating	No
8	22	Fracture comp. commin.	2 mos. (packed open)	2½ mos.	3 mos.	180–160	180– 90	.....	No
9	23	Fracture comp. commin.	No	5 mos.	7 wks.	180–160	180–40	Pain, grating	No
10	30	Fracture comp. commin.	No	1 day	7 mos.	Normal	180– 90	Gunshot wound	No
11	24	Chondromalacia	No	5 mos.	4 mos.	180– 70	180– 40	Pain, swelling instability	No
12	24	Chondromalacia	No	4 mos.	3½ mos.	180– 60	180– 40	Pain, swelling instability	No
13	26	Chondromalacia	No	10 mos.	2½ mos.	180– 45	180– 45	Pain, swelling instability	No
14	20	Chondromalacia	No	17 mos.	5 wks.	180– 45	180– 60	Pain, weakness	No
15	29	Chondromalacia	No	31 mos.	4 wks.	180– 60	180– 40	Pain, weakness swelling	No
16	20	Chondromalacia	No	5½ mos.	4 wks.	180– 45	180– 40	Instability, grating	No
17	28	Chondromalacia, tear internal meniscus	No	3 yrs.	4 wks.	Normal	180– 40	Instability, grating locking	No
18	26	Dislocation chondromalacia	No	4 mos.	9 wks.	175– 90	180– 70	Pain, grating	No
19	23	Fracture, simple nonunion	No	2½ mos.	2 mos.	165– 90	180– 40	Pain, grating	No

tion must be performed with the knee in full extension, since in flexion the slack will be lessened and the computations made become invalid. The plication is done with No. 00 silk, reinforced with single sutures. The subcutaneous tissue and skin are closed as usual.

Postoperatively the patient is immobilized in balanced suspension with the knee in full extension for 1 week and is then started on active exercises. Quadriceps setting is begun in 24 hours. Patients can usually begin weight bearing within 2 weeks.

The conditions for which patellectomy is most often indicated are recent comminuted fractures, old fractures with roughening of the articular surface of the patella or femoral condyles, chondromalacia patellae, and dislocations, habitual or recurrent, of traumatic, paralytic, or congenital origin. In addition, removal of the patella may be indicated in the treatment of degenerative arthritis, local septic lesions, and tumors of the patella.

CLINICAL MATERIAL

Nineteen total patellectomies are now available for study; data are presented in Table I.

In patients with chondromalacia patellae as the underlying pathological process, there

has been a normal range of motion preoperatively but with associated knee joint symptoms. Postoperatively, in all cases, there has been a rapid recovery of normal motion with a subsidence of all symptoms.

In those cases in which there has been limitation of joint motion preoperatively, as in the compound fractures, there has been a definite improvement in the range of motion although normal motion has not been attained. We believe that in these cases failure of return of normal motion is due to associated intra-articular damage found in all cases on the roentgenograms and at the time of surgery. In this respect it is noteworthy that there was normal motion preceding and following patellectomy in patient M.J., with a comminuted fracture of the patella due to a perforating bullet wound in whom there was no demonstrable associated joint damage. All patients have been relieved of their knee joint symptoms and excellent *function* has resulted in spite of the limitation of motion.

We have concluded that whereas in all cases the patient is alleviated of his knee joint symptoms, and has shown an improvement in, or normal restoration of motion, *this postoperative return of joint motion has been conditioned by the range of motion existing prior to surgery.*

CONCLUSIONS

1. While we hold no brief as to the incision used for removal of the patella, we believe that the median parapatellar skin incision and the longitudinal incision of the tendon are best adapted to the method of lateral plication.

2. The slack to be eliminated by the method of lateral plication has been computed to be 1.6 centimeters with the knee in full extension.

3. In this series of 19 patellectomies, (10 compound, comminuted fractures, 8 cases of chondromalacia, and 1 ununited simple fracture), all patients have been relieved of knee joint symptoms.

Whereas all patients have shown improvement in or normal restoration of function, postoperative return of function has been conditioned by the range of motion existing prior to surgery. Those patients who have had a normal range of motion before surgery will regain a normal range of motion following removal of the patella; those patients with limited motion preoperatively due to associated joint damage have shown a measurable improvement in range of motion.

BRONCHOPNEUMONIA FOLLOWING ETHER ANESTHESIA IN OBSTETRICS

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A SERIES of cases of bronchopneumonia has been observed in patients on the obstetrical service at Cleveland City Hospital. These bronchopneumonias, observed within a few days following delivery, were variable in extent, transient in nature, and were not associated with clinical evidence of serious illness. They were discovered in almost all cases by means of a roentgenogram of the chest made to investigate the significance of slight fever or râles in the chest developing after delivery. The anesthesia in these cases consisted of ether administered usually by the open method and preceded by varying quantities of barbiturate and other premedication. The mechanism by which the pneumonias were produced was probably the aspiration of mucus or vomitus during or following anesthesia. Other factors which may be considered are suppression of cough reflex and retention of secretions due to the irritation of ether.

Further study of these cases was undertaken because of the frequency with which they were observed, and because some of them were incorrectly diagnosed.

REVIEW OF LITERATURE

A search of the literature revealed that little attention has been paid to aspiration pneumonia as a complication of anesthesia in obstetrics. Hall, in 1940, called attention to aspiration pneumonitis as an obstetric hazard by reporting 15 cases of aspiration pneumonia following delivery. His cases were of a serious nature, since 5 died and several others required prolonged hospitalization. He commented that the aspiration of solid material into the trachea or bronchial tree might produce death from respiratory obstruction, while the aspiration of fluid material produced some sort of chemical pneumonitis. He discussed a number of factors, including diet prior to delivery, position of the patient during anesthesia, and premedication, which he thought might be related to the problem of aspiration of gastric contents. Autopsies were obtained in 2 of his 5 fatal cases. One showed "both lungs full of a diffuse wet consolidation with air present only at the extreme apexes." The second was found to have "both lungs collapsed, and the bronchi of each lung filled with dark colored contents, apparently spinach or some other dark food."

Meurlin, in 1941, reported a series of 7 deaths occurring in Essex County, New Jersey, in a period of 4 years, developing during or soon after labor, and directly caused by the aspiration of stomach contents. He stated that in addition to these 7 cases, many other deaths had occurred which were probably also of this nature, but which were not included in his report due to lack of accuracy of the available information or because of their controversial nature.

SUMMARIES OF TYPICAL CASES

CASE 1. V. M., a white woman 22 years of age, was admitted to the tuberculosis division of City Hospital on August 26, 1944. Four days prior to her admission, following a labor of 15 hours' duration she was delivered of a healthy infant at a maternity hospital elsewhere in the city. Ether anesthesia was administered for 40 minutes, preceded by seconal medication, and was followed by vomiting. Evidences of bronchopneumonia appeared, and on the day following delivery she was transferred to a general hospital. At this hospital, a roentgenogram of the chest made 2 days following admission showed irregular mottled and feathery shadows of increased density distributed symmetrically throughout all of both lung fields. Since the radiologist interpreted these changes as due to pulmonary tuberculosis, the patient was transferred to the tuberculosis division of City Hospital. On admission, she was afebrile, did not appear ill, but presented scattered inspiratory musical râles bilaterally. The admission roentgenogram of the chest, made 6 days following delivery, again showed diffuse bilateral mottled infil-

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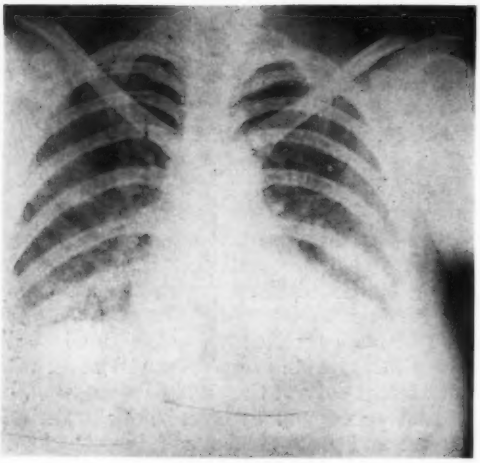

Fig. 1. Case 1. Extensive patchy symmetrical bilateral bronchopneumonia.

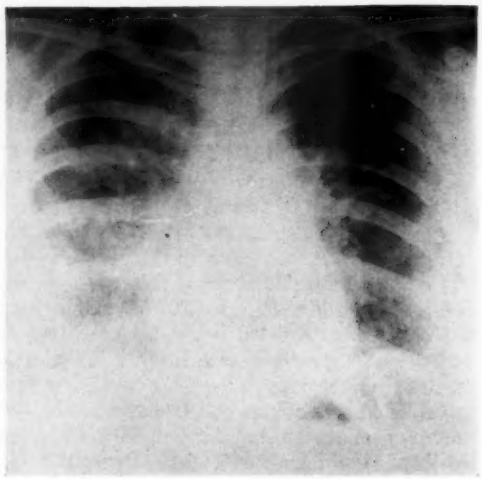

Fig. 2. Case 3. Dense coalescent infiltration involving lower two-thirds of right lung field, and left hilum.

tration, less extensive than that observed on the submitted roentgenogram. Because of the symmetry of her pulmonary disease, the healthy appearance of the patient, and the absence of pulmonary symptoms, pulmonary sarcoidosis was suspected. Another roentgenogram of the chest made 19 days following admission showed the pulmonary infiltration to have undergone complete resolution. Since the rapidity of clearing of the infiltration excluded both pulmonary tuberculosis and sarcoidosis, it was evident that the process represented a widespread bronchopneumonia. The patient was discharged on September 16, 1944, to the care of a private physician.

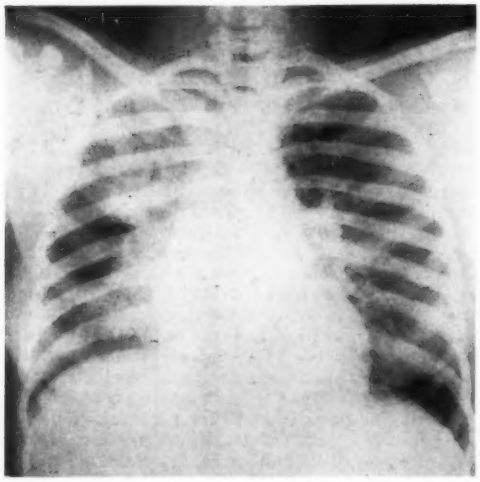

Fig. 3. Case 4. Dense bronchopneumonic infiltration in right upper and lower lung fields.

CASE 2. F. N., a colored woman 22 years of age, was admitted to the obstetrical service on March 23, 1944, in active labor. Seconal was administered in a dose totalling 3 grains as premedication. Delivery was effected following a labor of 3½ hours' duration. Ether anesthesia was employed. Vomiting of particulate and fluid gastric contents occurred during and immediately following anesthesia. Dyspnea and cyanosis developed. Bronchoscopic aspiration was immediately performed with relief of dyspnea, followed by the administration of sulfathiazole for a period of 3 days. The temperature rose to 38.8 degrees Centigrade for a period of 1 day, after which it remained normal. Scattered râles were present throughout the chest. The total white count on the day following delivery was 12,800 white cells per cubic millimeter. A roentgenogram of the chest made 1 day following delivery showed the presence of coalescent poorly demarcated shadows of increased density distributed symmetrically throughout both lung fields, interpreted as bronchopneumonia. Following the initial episode of obstructive dyspnea, the patient did not show evidence of serious illness. A second chest radiograph made 8 days following delivery showed complete resolution of the bronchopneumonia. She was discharged April 3, 1944, 11 days following her hospital admission.

CASE 3. D. T., a white woman 27 years of age, was admitted to the delivery room on March 21, 1941. Delivery was effected following a labor of 17 hours' duration. Inhalation gas oxygen ether anesthesia was used, preceded by morphine scopolamine medication. The anesthesia was complicated by

TABULAR SUMMARY OF 20 CASES

	No. cases
Extent of involvement	
One lobe or less	13
One lobe to one lung	5
Exceeding volume of one lung	2
Side involved	
Right	15
Left	2
Bilateral	3
Localization in lung field	
Upper	9
Lower	4
Midlung	1
Upper and lower	6
Involvement chiefly of right upper lobe	8
Density of infiltration	
Slight	12
Marked	8
Type of anesthesia	
Ether cone	15
Oxygen ether	3
Unknown	2
Preliminary medication	
Barbiturate	8
Morphine and scopolamine	4
No sedative medication	6
Unknown	2
Time of last meal	
Less than 6 hours before anesthesia	2
Over 6 hours before anesthesia	16
Unknown	2
Fever, duration	
No fever	1
Fever 1 day	9
Fever 2 to 3 days	6
Fever over 3 days	2
Unknown	2
Fever, height	
No fever	1
37 to 39 degrees Centigrade	11
39 to 41 degrees Centigrade	6
Unknown	2
Known to have vomited	9
Bronchoscopy performed	1
Chemotherapy	
Administered	11
Not administered	7
Unknown	2

vomiting. A roentgenogram of the chest made 3 days following delivery showed the presence of mottled and conglomerate shadows of increased density involving the lower two-thirds of the right lung field, and the left hilum area, interpreted as bronchopneumonia. Despite the extent of the infiltration as observed roentgenologically, the patient did not appear ill, and her temperature did not exceed 38.2 degrees Centigrade. An x-ray film of the chest made 4 days later showed the bronchopneumonia to have undergone complete resolution. She was discharged in good condition on April 4, 1941.

CASE 4. E. S., a colored woman 19 years of age, was admitted to the delivery room on February 12, 1945. Delivery was effected under ether anesthesia, preceded by atropine. The patient vomited shortly following delivery. Twelve hours later she developed

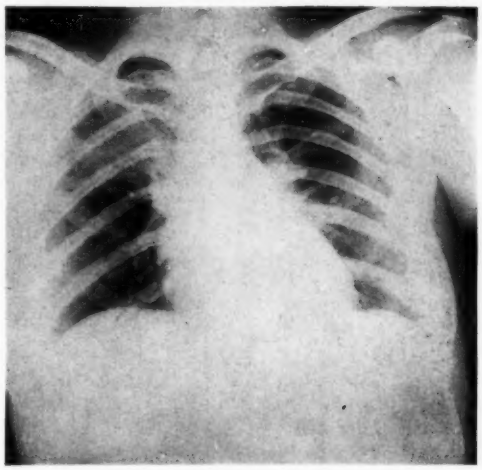

Fig. 4. Case 5. Dense infiltration situated in the right upper lobe.

a shaking chill, and her temperature rose to 38.8 degrees Centigrade. A roentgenogram of the chest made on the day of delivery showed mottled shadows of increased density in the lower and medial portion of the right lung field, and in the left hilum area, interpreted as bronchopneumonia. Sulfadiazine therapy was begun. The patient remained febrile for only 1 day, and recovered uneventfully. Another roentgenogram of the chest made 6 days following admission showed the pulmonary infiltration to have undergone complete resolution. She was discharged 8 days following admission.

CASE 5. B. J., a white woman 19 years of age, was admitted to the obstetrical service on November 9, 1943. She was delivered under ether anesthesia preceded by morphine scopolamine medication, following a labor of 15 hours' duration. After delivery, she developed fever rising to a maximum of 38.4 degrees Centigrade. A roentgenogram of the chest made 1 day following delivery showed a dense mottled infiltration in the upper lobe of the right lung, interpreted as pulmonary tuberculosis. Although she did not present clinical evidence of serious illness, she was treated with sulfathiazole for a period of 3 days. A second chest roentgenogram made 9 days following delivery showed the infiltration to have undergone complete resolution, indicating that the original diagnosis of pulmonary tuberculosis was erroneous. She was discharged in good condition on November 21, 1943.

EVALUATION OF STUDY

Information concerning the 20 cases comprising this series is included in the accompanying tabular summary.

Fig. 5. Symmetrical, dense, largely basal infiltration.

The frequent involvement of the right side as compared with the left may be explained by the more vertical course and larger caliber of the right main bronchus as compared with its fellow on the left. Similar predominance of right sided involvement has been observed in aspiration of foreign bodies and in lung abscess.

The lobar distribution of the aspiration pneumonias emphasizes merely that in bed patients such changes are not confined to the bases, but may occur anywhere in the lungs.

Fig. 7. Dense homogeneous infiltration in lower and medial portion of right lung field.

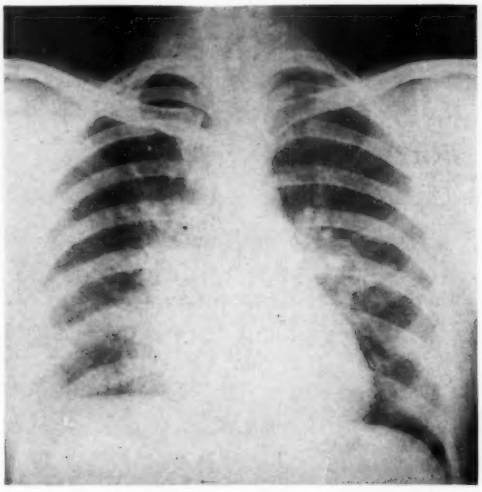

Fig. 6. Patches of infiltration in the right cardiophrenic angle and in the left first anterior interspace.

Gastric evacuation is normally complete in 6 hours. In 16 of the tabulated cases, no solid food was eaten within this period prior to anesthesia, and in only 2 cases was a meal eaten within 6 hours of the time of anesthesia. This would indicate either that solid food is unimportant in the pathogenesis of aspiration pneumonia, or else that gastric evacuation is prolonged in labor.

No conclusions can be reached concerning the possible importance of sedative medication in the pathogenesis of this condition. Approximately two-thirds of the patients had preliminary sedation, either by barbiturate or by morphine and scopolamine. The remaining third received no sedative medication. There was no correlation between the extent of the pneumonia and the quantity of sedative medication administered.

No difference was apparent in the clinical course of those patients treated with chemotherapy and those left untreated.

The early cases in this series, presenting localized pneumonic patches, were often confused roentgenologically with pulmonary tuberculosis. This was especially true when the infiltrations involved the upper lung fields. When observation on serial films repeatedly

demonstrated, by the rapidity of their clearing, their nontuberculous nature, the authors were inclined to dismiss them as small patches of atypical pneumonia or benign lobular atelectasis.

The observation of several extensive cases in which anesthesia was known to have been complicated by vomiting and aspiration of vomitus clarified the nature of the small infiltrations previously observed. These patients, who presented roentgenologically extensive symmetric pulmonary densities closely resembling pulmonary edema, showed no clinical evidence of serious illness and achieved an uneventful recovery without specific treatment. The similar course of the extensive and the localized pulmonary lesions suggested that they probably had a common etiology, namely, aspiration of vomitus or mucus during anesthesia.

Vomiting is known to have occurred during anesthesia or labor in 9 of the 20 cases in this series. It is possible that in additional cases vomiting took place prior to anesthesia or following its completion, but was not recorded. It is also possible that the aspiration of mucus, in the absence of frank vomiting, may result in aspiration pneumonia.

Karsner describes aspiration pneumonia as due to the lodgment of food particles and exudate of pharyngeal inflammation in a distal portion of the bronchial tree, resulting in a patch of bronchopneumonia in the pulmonary area drained by this bronchial branch. The peculiarities of such a patch of bronchopneumonia are, according to Karsner, its subpleural location, its conical shape, and its tendency to subsequent suppuration.

Irons and Apfelbach, in a study by autopsy of aspiration pneumonia, found that this condition was present at autopsy in about 20 per cent of their material. They based their diagnosis of aspiration pneumonia upon a number of diagnostic criteria, notably: (1) intense hyperemia, with extensive hemorrhage and edema of the alveolar spaces, (2) evidence of hemolysis, due to alteration of blood by the aspirated material, (3) patchy distribution of the involved areas, (4) desquamation of bronchial mucosa, (5) undue degree of postmortem change of the tissues, (6) presence of food particles and of bacterial masses in the involved areas, (7) heterogeneous nature of bacteria present as determined by culture.

Apfelbach and Christianson found, in a series of incompletely reported experiments on dogs, that the aspiration of gastric juice containing normal quantities of hydrochloric acid produced a temporary hyperemia of the lungs, but did not result in death. Death occurred in animals only if stomach contents containing bacteria were used.

Fetterman and Moran found an incidence of 5.7 per cent of food aspiration pneumonia in a series of 469 autopsies, constituting 12.7 per cent of the cases of terminal bronchopneumonia present in this series. Since their diagnosis was based solely upon the finding of food particles as identified on routine microscopic sections, this study minimizes the actual incidence of aspiration pneumonia in an autopsy population.

ROENTGENOLOGIC FINDINGS

The bronchopneumonias observed in this series of 20 cases have been variable in extent and in density. In 13 cases the infiltration involved an area less extensive than the volume of one lobe of one lung. Five additional cases presented more extensive lesions not exceeding the volume of one lung, while 2 extensive cases presented diffuse shadows occupying virtually all of both lung fields. In localization, involvement of the right side was more frequent than that of the left, involvement of the upper lung more frequent than the lower, and the most frequent single site of localization was the right upper lobe area.

The less extensive cases have presented the picture of "soft" fluffy localized shadows of increased density which, when situated in the upper lung fields, closely simulate the early infiltrations of adult tuberculosis. The more extensive bilateral cases have shown symmetric extensive coalescent densities, with a tendency to central localization, simulating the picture of pulmonary edema. A variety of intervening patterns have also been seen, which cannot be distinguished from bronchopneumonias of other causes. Usually an associated generalized increase in prominence

of the vessel markings has been found, suggestive of pulmonary hyperemia. None of the patients have shown mediastinal displacement or other evidence of massive atelectasis.

Clearing of the infiltration was rapid in most cases and complete in all. Fifteen of 18 cases in which serial films are available showed complete clearing in 1 week or less. The time of clearing in the other 3 cases is not known with certainty, but complete disappearance of the infiltration was demonstrated on the eighth, ninth, and twenty-first days, respectively.

On strictly objective criteria, a roentgenologic diagnosis of aspiration pneumonia is not possible, but its recognition is usually easy if the roentgenologist has the clinical findings available to him, and if he is familiar with the condition. It may be confused chiefly with pulmonary tuberculosis, sarcoidosis, atelectasis, pulmonary edema, and other pneumonias. It is differentiated from both pulmonary tuberculosis and sarcoidosis by its rapidity of clearing as seen on serial films. It differs from lobar or massive atelectasis in its patchy character and in the absence of mediastinal displacement. Dependence must be placed upon the clinical findings to differentiate it from bronchopneumonias and pulmonary edemas of other etiology.

It is evident that a roentgenogram of the chest made shortly following delivery may be a confusing diagnostic measure if its purpose is the detection of early pulmonary tuberculosis. Chest roentgenograms made for this purpose should be taken either prior to delivery or 2 weeks or more following delivery.

CLINICAL ASPECTS

The immediate sequel to vomiting during anesthesia has been respiratory distress. In 1 of the cases, this distress was sufficiently serious to require bronchoscopic aspiration for relief. In the remainder, more simple measures proved adequate. There were no fatalities in this series, although the possibility of an immediately fatal issue is indicated by the reports of Hall and of Meurlin.

The height of the fever manifested in these cases is indicated in the accompanying tabular summary. It was unusual for fever to be sustained at a high level; most of the patients presented one or several spikes of fever with prompt fall either to normal or to a level below 38 degrees Centigrade. None presented the appearance of serious illness, and in none were clear-cut localized physical signs of consolidation, other than râles, discovered. A slight leucocytosis, averaging 10,000 to 12,000 white cells per cubic millimeter, was present in some.

PATHOGENESIS

Two chief questions arise concerning the origin and nature of these bronchopneumonias, namely, what is the nature of the pathologic change in the lungs, and what is the explanation for the benign clinical course observed in these patients?

It is generally recognized that, in addition to the classical forms of massive atelectasis, smaller areas of lobular or patchy atelectasis may occur as the result of occlusion of finer bronchiolar radicles. It is probable that the shadows seen in the roentgenogram are in part due to such patches. Another factor contributing to the pulmonary changes is the reaction of the lung tissues to the irritant gastric contents, namely, hyperemia, hemorrhage, edema, and exudation. Finally, areas of bacterial pneumonia may occasionally supervene in areas in which virulent organisms have been implanted.

The failure of the cough reflex to expel the foreign material from the bronchial tree is probably in part due to the massiveness of the aspiration, and in part to the fluidity of the aspirated material. Archibald and Brown have shown that cough, instead of expelling material from the bronchial tree, may actually cause it to be driven deeper into its ramifications. In their experiments upon animals, iodized oil was disseminated in the bronchial tree by cough, while thick tenacious sputum, being a heavier substance, was expelled. The dissemination of iodized oil by cough is a matter of common observation in bronchography. On the basis of the experiments of Archibald and Brown, it is probable that gastric contents, because of their fluid nature and slight viscosity, are widely disseminated in the bronchial tree by cough, and inefficiently and incompletely expelled.

The benign course of these bronchopneumonias has been noteworthy. One factor responsible is their incidence in a group of young healthy women without evidence of cardiac or pulmonary disease. A more important factor is the probable presence in these patients, because of their age, of an adequate gastric acidity, inhibiting the growth of pathogenic bacteria.

Other than coincidence (suggested by the reported deaths in other series), the only factors known to have prevented immediate death from asphyxiation have been postural drainage of the bronchial tree, and its aspiration by catheter suction, in 1 instance bronchoscopically, for relief of respiratory distress.

FACTORS PECULIAR TO OBSTETRICAL ANESTHESIA

A number of factors may play a part in the frequency of aspiration pneumonia in obstetrical cases. First is the frequent necessity for administering an anesthetic when the patient's stomach is laden with food. Second is the possible effect of premedication by barbiturate or by morphine in depressing protective reflexes or inducing vomiting. Third, the depth of anesthesia demanded in good obstetrics is dangerously near the level at which vomiting may readily occur, even when expertly administered. Daily observation suggests that the time of gastric evacuation is prolonged in labor, and Meurlin states that "a delayed emptying time of the stomach during labor is a factor which should be kept in mind." Finally, vomiting is occasionally seen in the latter part of the first stage of labor, and during the portion of the second stage of labor preceding anesthesia. This may occur independently of medication, and is probably of reflex origin.

PREVENTION AND TREATMENT

The well known measures of postural drainage of the bronchial tree and its aspiration by catheter suction or bronchoscopically are the recognized methods of treating vomiting and aspiration during anesthesia.

The aspiration pneumonias in this series have not been of sufficient clinical severity to require the use of chemotherapy, nor did chemotherapy affect the course of those patients in which it was used.

The administration of an emetic in early labor to the woman who has recently eaten solid food has been practiced in this community. Gastric evacuation by induced emesis, when carefully executed, might prevent the postanesthesia vomiting and aspiration of particulate matter.

The properly trained anesthetist will be able in most instances to maintain his patient in the narrow zone of anesthesia in which the labor processes are allowed to continue without the development of vomiting.

SUMMARY AND CONCLUSIONS

1. A series of 20 cases of bronchopneumonia was observed at Cleveland City Hospital, which developed following obstetrical delivery in which ether inhalation anesthesia was used.

2. Their chief cause was the aspiration of gastric contents as a result of vomiting. The possible contributory rôle of the following factors was discussed: (1) preanesthetic medication, favoring suppression of the cough reflex, (2) prolonged gastric evacuation in labor, (3) fluidity of gastric contents, favoring their dissemination in the bronchial tree.

3. The bronchopneumonias varied in extent from small isolated patches to extensive bilateral infiltrations. They were observed in all portions of the lung fields.

4. Clinically, they did not prove a cause of serious illness and no fatalities resulted. Chemotherapy by sulfonamide drugs was apparently not effective.

5. Roentgenologically, the problem was one of differential diagnosis, requiring differentiation from pulmonary tuberculosis, sarcoidosis, other pneumonias, pulmonary edema, and atelectasis.

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THE RETROGRADE LYMPHATIC SPREAD OF CARCINOMA OF THE "RECTOSIGMOID REGION"

Its Influence on Surgical Procedures

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FEW organs of the body have been subjected to more intensive and exhaustive study in recent years than has the rectum. This is particularly true with reference to carcinoma and its potentialities in this region. Needless to say, we are still far removed from an understanding either of its cause or of its specific cure, although admittedly great strides have been made, especially with regard to its surgical treatment. Those advances that have been made are based on a more thorough understanding of the nature of cancer of the rectum, including the form which it is likely to assume, its rapidity of growth, its mode of spread and its final outcome. Here as elsewhere, it has been learned that malignant disease, with perhaps some few exceptions, can be adequately controlled only by complete extirpation; hence the innumerable surgical methods and modifications that have come into practice.

Moynihan, in 1908 made the significant statement that "the surgery of malignant disease is not the surgery of organs; it is the anatomy of the lymphatic system." Nowhere is this more applicable than to malignant disease of the rectum. It is toward the anatomy of the lymphatic system that the greater portion of this study has been directed. Many investigators in the past and present have devoted much of their time to its study and the results of their work as well as the conclusions of this research will be correlated in an attempt to determine what an adequate method of treatment for carcinoma of the rectum and particularly of the rectosigmoid region implies.

From the Mayo Foundation and the Division of Surgery, Mayo Clinic.

Abridgment of thesis submitted in September, 1944, by Dr. Glover and accepted in November, 1944, by the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of M.S. in Surgery.

If, as has been the dream of surgeons for many years, cancer of the rectosigmoid and upper part of the rectum with its involved diseased region can be removed, with restoration of normal continuity to the bowel and preservation of sphincteric control, a great contribution will have been made. It was with such an aim in view that this study was undertaken, for should it be feasible from a pathologic standpoint an impetus for refinements in surgical attack and technique will surely follow. As carcinoma of the rectum represents some 4 per cent of all cancers (1, 15), it is evident that the number of patients who might be concerned is considerable and any pathologically sound attempt to avoid the construction of an artificial anus will be well repaid. Such attempts have been numerous and with good result when properly carried out but have been frowned on by many who believe them to be more sensational than radical, basing their belief primarily on the work of Miles.

SPREAD OF CARCINOMA

Malignant disease may spread primarily in one of three ways: by local extension from its site of origin, by invasion of venous channels, and through the lymphatic system. An evaluation of any therapeutic approach to carcinoma in a given region must therefore take into its scope each of these avenues. Although an extensive literature concerning the first two of these modes of spread exists, the original work of this paper deals only with certain aspects of lymphatic spread and consequently discussion other than of the lymphatics must necessarily be limited to a few short statements.

Local extension. Carcinomas of the rectosigmoid are relatively slow-growing malignant lesions. Microscopically three quarters of

them are of low grade, so that one would expect considerable local growth before any widespread metastasis has occurred. W. J. Mayo (25) emphasized this point in 1910 and reiterated it repeatedly (26, 27), as have other writers (4, 33). Indeed, in his experience, local extension more than any other factor, including lymphatic and hepatic involvement, was the common cause of inoperability. That distant metastasis may occur while the mass of the disease remains localized is of course well recognized and indisputable but, by and large, it may be stated that a considerable period elapses in most cases before this occurs. It is obvious, therefore, that all locally involved tissues must be removed at the time of operation and to accomplish this end it is absolutely essential that wide excision through healthy tissues be practiced.

Venous spread. Once carcinoma has spread into venous channels with the formation of malignant thrombi and dispersion of malignant emboli, no surgical procedure, however radical, can be devised to rid the patient of his affliction. Were such a sequence of events customary, the prognosis for cancer of the rectum would indeed be grave. Fortunately this does not obtain, although investigations within the last decade tend to show that it is a more frequent occurrence than was formerly suspected.

Intravascular invasion seems remarkably constant, occurring in approximately a fifth of all cases of malignant lesion of the lower part of the colon (8, 13, 34). As would be expected, the higher the grade of malignancy, the higher becomes the incidence of venous involvement and the greater the probability of visceral metastasis (3).

Perhaps the most significant observation concerning venous spread was made by Clogg in 1904. He noted that when dissemination via the blood stream occurred it frequently did so before the disease had spread to lymph nodes. Recent studies (13) have confirmed this impression and enlarged on it to show that most vascular invasion originates within the involved intestinal wall itself or within the immediately adjacent perirectal tissues and not from more distant extensions. Consequently, although sharply limited and seemingly favorable for surgical removal, a rather innocuous-appearing cancer may prove as deadly as the most widespread and perforating types. Such cases explain why the rate of cure declines in direct proportion to the degree of penetration even though no involvement of perirectal fat or lymphatic network be found. It must be obvious therefore that the threat of venous spread demands early rather than radical surgical intervention, the latter being directed more especially against local and lymphatic expansion.

Lymphatic spread. As carcinoma spreads through the ramifications of the lymphatics in a most systematic and relentless manner, the problem of its control must be met with equal thoroughness and determination. To do so entails an intimate knowledge of all pathways over which such an advance may occur. The literature contains several detailed and exact studies (9, 32, 35) to which reference may be made with considerable profit and from them Figure 1 has been constructed.

Anatomic review. Considering the anus and rectum as one continuous tube, it may be divided into three regions corresponding roughly to the areas supplied by the inferior, middle, and superior hemorrhoidal arteries. The inferior region is the 2.5 centimeters of anus proper terminating superiorly at the pectinate line. The middle region extends upward from the pectinate line to a point just above the insertions of the levator ani muscle. The superior region extends from this point to the sigmoid colon and terminates approximately at the level of the third sacral vertebra. This latter is the largest of the three regions.

The lymphatics in all of these regions originate in a rich network of tiny lymph spaces, the extremely close meshes of which extend throughout the mucosal, submucosal and intermuscular layers. Although continuous diversified connections of this network have been said to exist between all three regions, for the most part they may be found to unite into their own collecting trunks, which further join to terminate in lymph nodes after the full thickness of the intestinal wall has been traversed. Thus the direction of flow is essentially at right angles to the long axis of the bowel,

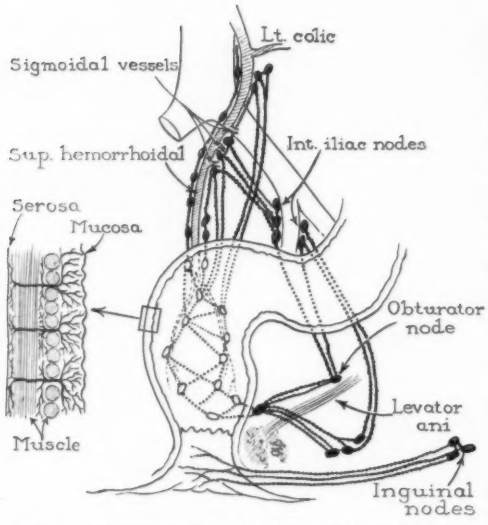

Fig. 1. The extramural and intramural lymphatic systems of the rectum (intramural system after Leitch).

even though many small intermediary branches may course in any direction en route to their final destination. In other words, lymph potentially able to spread from anus to sigmoid in whole or part via these small channels never does so, a point which will be discussed in some detail presently under intramural spread. Having thus arrived in the collecting trunks drainage proceeds according to definite pattern.

1. Inferior and middle regions. Although drainage from the inferior and middle regions is not strictly a concern of this work, it may be pointed out in passing that most if not all of the lymph originating in the region at the same level as, or immediately above, the insertions of the levator ani flows upward, joining the pathways of the superior region. Some may, however, spread laterally along the levator muscles, either superior or inferior to them, and some may also spread caudally through the adipose tissue of the ischiorectal fossa. Thus the lymphatic pattern of the middle region might possibly in certain instances be designated as being "perineopelviabdominal" (Fig. 1).

2. Superior region. Numerous efferent trunks pass through the muscular coat at different levels. Most frequently these trunks become satellites of the branches of the superior hemorrhoidal vessels, usually two for each artery. After perforating the rectum they run obliquely upward and backward to reach the nodes in the mesorectum. In their perirectal course they traverse several small nodes placed on the muscular layer and covered by the serous coat of the rectum (pararectal nodes of Gerota). These nodes are found especially in the region of the ampulla, the lowest immediately above the levator ani. The superior nodes, however, may be found projecting underneath the serous coat and are minute. The true mesorectal nodes of considerable size are usually grouped around the superior hemorrhoidal artery and may be regarded as the true regional nodes of the superior region of the rectum. The flow of lymph in these channels is upward, although it is conceivable that a dam or block to the natural upward course might cause lymph to flow in a retrograde manner. Normally, however, the lymphatic drainage of the superior region of the rectum is only abdominal in direction (35), a point which cannot be too strongly emphasized. Whereas drainage from the inferior and middle regions of the rectum may be perineopelviabdominal with anastomoses in the posterior part of the vagina and the levator ani muscles, drainage from the upper part of the rectum has no direct anastomosis with pelvic organs unless it be by long, tedious and unnatural retrograde flow down the surface of the rectum in the face of complete upward blockage as suggested previously.

Pathologic consideration. Having thus become well versed in the normal course of lymphatic drainage in and from the rectum it is now possible to appreciate more fully how malignant processes avail themselves of these channels. Discussion will be greatly facilitated by dividing the lymphatic system as a whole into intramural (from mucosa to serosa) and extramural (from serosa to regional nodes) components.

1. Intramural (Fig. 1). Carcinoma of the rectum takes its origin from altered mucosal cells of the rectal lining, usually stated as arising deep in the crypts of Lieberkuehn. From this tiny focus it may spread either by direct

extension and invasion of small lymph meshes from its margins or directly through the thickness of the rectal wall. Marginal extension is greater and more rapid transversely around the bowel than through the rectal wall but even transverse extension is extremely slow, 6 months being the estimated time for carcinoma to travel approximately a quarter of the way around the lumen. Advance through the submucosal and muscular layers is equally slow and the serosal covering has usually not been reached until the growth has traversed three quarters of the circumference of the bowel or until some 18 months have elapsed. The circular and longitudinal muscles are pierced by radial channels, thus giving free communication for malignant cells to travel between submucosal, intermuscular, and subserosal plexuses.

Cole was able to show that, whereas carcinoma spread more widely in the submucosa than on the mucosal surface and still more widely in the muscularis, there was no evidence of longitudinal permeation of the intestinal wall beyond the microscopic edge of the growth. Other studies appearing at approximately the same time all substantiated this view (5, 22, 30). Monsarrat and Williams demonstrated that as a rule longitudinal spread occurs only to the distance of about 2 centimeters above or below the gross mucosal edge of the lesion and that this invasion is greatest in the subserosal portion. In more recent years ample evidence (12, 20, 21, 24, 29) has accumulated indicating the improbability of any widespread dissemination along the course of intestinal walls comparable to the spread along the wall of the stomach that may occur in cases of gastric carcinoma. Apparently, described anastomotic channels to any great distance are potential rather than actual. Leitch has expressed the belief that the lymphatics of the mucosa do not exist as a continuous plexus but are arranged in a decussating arborescent pattern from the collecting stems which pierce the circular muscular coat. Spread in the intermuscular lymphatics is just as limited (Fig. 1). It may, therefore, be stated that intramural dispersion alines itself closely with observed gross and microscopic extensions of the growth and plays no part in the demand for extensive radical surgical intervention.

2. Extramural. By far the most important mode of extension, extramural spread has accordingly been the subject of most well directed research to date. Because of its supposedly widespread potentialities carcinoma at the rectosigmoid juncture has for the most part been subjected to the same treatment as has carcinoma lower in the rectum with removal of perianal skin, rectal sphincter, and the whole pelvic colon. Evidence in the literature combined with that of this study will demonstrate rather conclusively, however, that many growths high in the rectum lend themselves admirably to procedures far less radical than this and more acceptable to the patient but equally effective as far as the disease process is concerned. Close scrutiny and attention to detail will reveal a loophole which up to the present, although noted by several investigators, has failed to become widely recognized as such. True it is that a few surgeons have explored these possibilities to their own satisfaction but the majority either are unaware of the opportunities afforded or have been misled by existing pathologic studies.

In accord with anatomic findings Miles observed that malignant processes might extend in an upward, lateral, or downward direction although in his study he made no attempt to give the exact location of the lesions employing these various pathways. The common course is upward, for it occurs in every case regardless of the site of the lesion from anus to sigmoid.

Lateral dissemination refers to that which courses along the levator ani muscles, the coccygei, base of bladder, cervix or base of the broad ligaments to terminate in the internal iliac nodes. Miles has encountered such involvement in several cases both in that portion of the levators immediately adjacent to the bowel and far laterally near the pelvic walls. Gilchrist and David made similar observations in 4 cases of their series, Coller, Kay and MacIntyre in 6, and Gordon-Watson and Dukes (18), in 1 case. That lateral dissemination may occur therefore is unquestioned and when one is dealing with low-lying growths it must be given due consideration.

TABLE I.—INCIDENCE OF RETROGRADE NODAL METASTASIS IN CARCINOMA OF RECTUM AND RECTOSIGMOID: REVIEW OF LITERATURE

	Total cases	Positive nodes—cases	Nodes involved below lesion—cases	Distance below lesion—cm.	Site of lesion
McVay, 1922	100	47	1	0–1	Ampulla
Wood and Wilkie, 1933	100	51	0	—	—
Westhues, 1934	74	?	1	1	?
Gabriel, Dukes and Bussey, 1935	100	62	2	0–1	Upper rectum (8 and 9 cm.)*
Gilchrist and David, 1938	25	16	2	2 and 4	Ampulla
Coller, Kay, and MacIntyre, 1940	33	22	1	1.5	Rectosigmoid
Grinnell, 1942	75	41	1	1	Ampulla (6 cm.)*
Total of cases in the literature	507	239+	8		
Glover and Waugh, 1944			27	0–1	Upper rectum, rectosigmoid and lower sigmoid
			6	1–2	
			1	2–3	
			1	3–4	
			1	6–7	
Total of Glover and Waugh's data	100	100	36		

*Above the pectinate line.

Downward invasion, as Miles used the term, refers to spread along the inferior hemorrhoidal vessels through ischiorectal fat and Alcock's canal, eventually to internal iliac nodes. Miles discussed 1 specimen removed by abdominoperineal resection in which the cancerous process had taken such a course. Other evidence that he presented was derived from records of postoperative recurrent growths occurring in the posterior wound. Whether these growths may be regarded as of true lymphatic origin or as occurring by direct invasion is a matter for debate. Gordon-Watson and Dukes were undecided, as spread in 2 of the 3 cases in which they noted ischiorectal involvement appeared more likely to be by direct continuity.

The long, unbroken chain of lymph nodes originating in the small pararectal nodes of Gerota deeply placed in the pelvis posterior to the rectum and extending through the larger superior hemorrhoidal group on into periaortic channels constitutes the upward and primary lymphatic drainage of the rectum. Neoplastic lesions situated anywhere within the pelvic colon sooner or later advance over this well traveled route. In the upper part of the rectum it is the *only lymphatic avenue available* for malignant invasion unless, on further investigation, ideas concerning the importance of recently described perineural or perivascular (34) networks are confirmed.

This upward spread proceeds in an orderly manner so that on specimens from cases of advanced carcinoma there is a sequence of involved nodes stretching from the primary growth to the point of ligature of the inferior mesenteric vessels. This procession is usually from node to node but occasionally it is discontinuous with considerable intervening gaps, due to the presence of several upward tracks running so to speak over the same roadbed. Numerous paths course directly to nodes at the bifurcation of the superior hemorrhoidal vessels, a few to the junction of the superior hemorrhoidal and lowest sigmoidal vessels, by-passing all nodes en route, and others to the junction of the left colic and inferior mesenteric vessels. Thus on occasion, intervening uninvolved nodes have been observed, so that it is impossible to state which node is the highest seat of metastasis unless all to a considerable height have been examined. Examples of this pattern have been shown by Grinnell, Gabriel, Dukes, and Bussey (14), Wood and Wilkie, as well as many others.

As no anastomoses of the lymphatics of the upper part of the rectum with those of pelvic organs exist, no lateral spread of carcinoma of the upper part of the rectum as described previously can occur via the lymphatics. Invasion by direct continuity may and does of course take place in direct proportion to the age of the growth.

Downward or retrograde spread along the course of the bowel through pararectal nodes, although normally nonexistent, may under certain circumstances be observed. In cases of advanced carcinoma in all probability beyond the realm of surgical cure, when the superior hemorrhoidal and inferior mesenteric nodes all or in great proportion become clogged with extensive metastasis, cancerous cells may take the course of least resistance, downward in this instance, over the same pathways which normally carry only one-way traffic—upward (17). Examples of this in the literature are rare and may be seen in Table I. There it will be noted that only 8 such cases have been observed, the node at 4 centimeters below the lesion (Gilchrist and David) probably being the only true demonstration of such retrograde flow. If, therefore, retrograde metastasis is so rare and there are no other lymphatic anastomoses between the upper part of the rectum and pelvic structures, should it not be reasonable that such facts be more widely applied in the surgical attack on lesions of the upper part of the rectum and rectosigmoid region? In order to be certain that such a stand could be taken on factual pathologic evidence and in the feeling that examination of the portion of the rectum and perirectal tissues lying between the lower part of the sigmoid and the insertion of the levator ani muscles would give the crucial answer, long and tedious study was directed at this region by means of the following procedures.

TABLE II.—RETROGRADE LYMPHATIC SPREAD IN 100 CASES OF CARCINOMA OF THE RECTOSIGMOID BY GRADES (BRODERS)

Microscopic grade	Total cases	Nodal involvement below lesion—cm.				
		0–1	1–2	2–3	3–4	0–7
1	25	6	1*	—	—	—
2	48	13	—	1	1	—
3	17	6	1	—	—	1
4	10	2	4	—	—	—
Total	100	27	6	1	1	1

*See report of Case 7.

MATERIALS AND METHODS

One hundred surgically removed rectums containing adenocarcinoma of the upper part of the rectum, the rectosigmoid, or the lower part of the sigmoid were obtained from the Division of Surgical Pathology of the Mayo Clinic. An attempt was made to secure only those specimens which represented far advanced disease so that the greatest possible spread of neoplastic cells might be contained therein. A choice from 2,206 such specimens was made, only those removed by combined abdominoperineal technique being used to be assured of the maximum tissue for dissection.

That these specimens constituted a group containing most extensive malignant lesions is evidenced in several ways. All of the adenocarcinomas were of Duke's type C (11); that is, all had metastasized to adjacent and regional lymph nodes. Grossly, 99 were ulcerative and 1 was polypoid. Ulcerative lesions of the colon are the most malignant and invasive type. Twenty-nine had advanced to perforation. Eighty-three of the ulcerative lesions were annular. As to their site of origin in the upper part of the rectum and above, 9.5 centimeters was the average distance from the lower gross mucosal edge of the lesion to the anorectal or pectinate line. This fact was ascertained by measurements of the formalinized specimens as well as by those recorded on the pathologist's report made at the time of operation and further corroborated by proctoscopic examination before operation.

It was originally intended to select the cases in equal number from each of the four grades of malignancy as classified by Broders, thus making comparison of results more uniform than it would be otherwise. However, as 75 per cent of rectal lesions are of low grade (1 and 2) it was impossible to secure enough specimens of the higher grades (3 and 4) which had not previously been used for other studies to fill in the required quota. Rather than sacrifice accuracy for statistics, all those lesions of higher grade which fulfilled the pre-

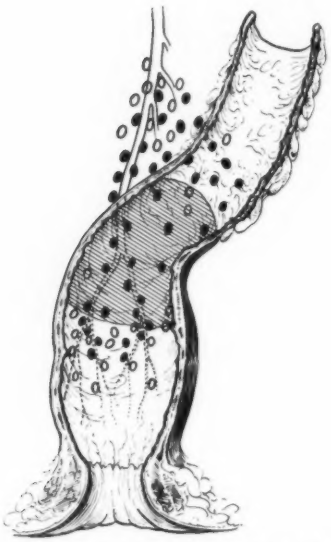

Fig. 2. Case 1. Location of the carcinoma with reference to the bowel, lymphatic and vascular systems (carcinoma, shaded area; involved nodes, black dots; uninvolved nodes, open dots).

viously stated requirements were chosen first —27 in number—and the difference up to 100 —73 cases—was obtained from the more plentiful carcinomas of low grade (Table II).

Two methods for the complete examination of the lymphatic region of an organ are available. The injection method, the one most recently used and especially adapted to the examination of fresh tissues, is that described by Spalteholtz and modified by Gilchrist and David. This type of investigation is accurate and has enabled its advocates to find many more nodes than they were previously able to locate by gross dissection of fresh specimens.

The other method is the more time-consuming and laborious gross dissection. This is the only method which can be used for tissues long immersed in formalin and may with application produce as satisfactory results as the injection method. Suffice it to say that the dissection method yielded results quite comparable to any other, for in those 5 cases of this series in which all the nodes on the entire specimen were examined an average of 60 nodes per specimen was found, the largest number being 82, the smallest 44.

By gross dissection then each of the 100 specimens was minutely examined from the lower gross mucosal edge of the lesions present to the anus. Serial sections were cut, each approximately 1 centimeter in width, the incisions beginning in the perirectal fat and being carried into the mucosa. The numerous slices thus produced were allowed to remain hinged on the mucosa so that accurate measurements could be taken concurrently. All lymph nodes were removed and each was carefully labeled not only as to its relationship to the lesion itself but also as to its position on the vascular tree. From these data all nodes were charted on diagrammatic sketches of the pelvic colon which were drawn to scale and on which each lesion had previously been outlined also according to scale. An average of 11 nodes per specimen was found between the limits outlined previously, the largest number being 53, the smallest, 2. A total of 1,339 nodes was found during the course of the whole study including nodes examined behind and above the lesions in the few cases indicated later.

Each node was then subjected to microscopic examination by the frozen section technique used in this case for screening those nodes metastatically involved from those uninvolved. All nodes containing any evidence of cancerous cells were further sectioned and stained with hematoxylin and eosin for study. Those found to be free from involvement were not examined further. One thousand four hundred seventy-nine sections were made.

RESULTS OF STUDY

In 64 cases there was no spread distal to the lower gross mucosal level of the lesion but in 36 cases there was distal spread. In 27 of the 36 cases the nodal involvement was within the first centimeter and no lower, in 6 it was between 1 and 2 centimeters but no lower and in 1 case each it was between 2 and 3 centimeters, 3 and 4 centimeters, and 6 and 7 centimeters.

All those cases in which there were positive nodes from the lesion to 2 centimeters but no lower were considered to be of no particular significance for the reason given previously in the section on intramural spread. It will be

remembered that as malignant invasion proceeds from the mucosal to the serosal surface of the intestinal wall it does so in a more or less triangular fashion, the base of the triangle being placed longitudinally along the long axis of the bowel in the perirectal fat at the serosa. In advanced lesions such as these the greater involvement in the perirectal fat and serosa as compared with involved mucosa always extended 1 centimeter below and above the longitudinal diameter of the lesion as measured on the mucosa, frequently extended to 2 centimeters in either direction and was occasionally seen at 3 centimeters. As a consequence all nodes within the first centimeter were found to be imbedded in carcinomatous tissue so that their removal for microscopic examination was in reality of academic interest only. Four of the 6 cases in which lymphatic spread was 1 to 2 centimeters were in this same category. In the other 2 cases the involved nodes were immediately adjacent to, but not actually imbedded in, carcinomatous tissue. The nodes from the 3 cases in which nodal involvement was more distal, however, were further removed from directly involved tissues although malignant extensions from the local growth were considerably closer than the indicated distance as measured from the lower *mucosal* level of the lesion. In summary, therefore, of the 100 cases in which the tissues were thoroughly examined only 3 could be classified as exemplifying true retrograde metastasis of any significance.

The obvious question now arises: Why did retrograde lymphatic permeation occur in 3 cases and not in the others? This problem entailed the re-examination of those tissues in which retrograde spread had occurred. For the sake of obtaining more complete evidence and also because 2 of the 6 cases with spread to 2 centimeters might be construed as instances of downward spread, all cases in which the distance was more than 1 centimeter were included in this additional study. In the same manner as has already been described all remaining nodes on the 9 specimens in question except as indicated, were removed and subjected to sectioning and charting. A detailed report was prepared for each case, consisting of both clinical and pathologic features as they applied in each instance.

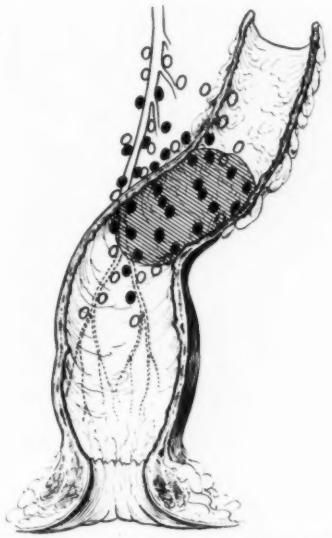

Fig. 3. Case 2. For explanation see legend of Figure 2.

REPORT OF CASES

CASE 1. A white woman, 61 years of age, registered at the Mayo Clinic July 14, 1917, with a chief complaint of "rectal stoppage." A detailed history revealed 1 year of rectal bleeding, suprapubic uneasiness, ribbon-like stools and finally almost complete obstruction, and loss of 29 pounds (13.2 kgm.). Physical examination gave negative results except for a large, hard, fixed encircling mass high in the rectum. On July 23, 1917, one stage perineoabdominal resection was performed. During the operation a small suspicious nodule was felt in the liver. The patient was dismissed from the clinic on August 31, 1917, after an uncomplicated recovery. The last report indicated her death in November, 1917. No details were given. Grossly the surgical specimen contained a very extensive, annular, ulcerative lesion 7 by 6 by 4 centimeters, mucosal measurement, 6 centimeters above the pectinate line. A total of 70 lymph nodes were found. Microscopically the lesion was an adenocarcinoma, grade 4 (Broders). For distribution and involvement of nodes see Figure 2. The lowest involved node was found between 1 and 2 centimeters below the lower mucosal edge of the lesion.

CASE 2. A white man, 36 years of age, registered at the clinic April 25, 1934, with a chief complaint of constipation after 6 months of blood-streaked, mucoid rectal discharges, dull abdominal aches and pains, increasing constipation and loss of 7 pounds (3.2 kgm.). Physical examination gave essentially

Fig. 4. Case 3. A cross section through the perirectal tissues at about the midportion of the lesion as illustrated in Figure 5. The solid carcinomatous area on the left corresponds to the double crosshatched area in Figure 5. The two nodes to the right above are also represented in Figure 5. They were found to be completely replaced with cancer cells. The block to the upward flow of lymph is obvious.

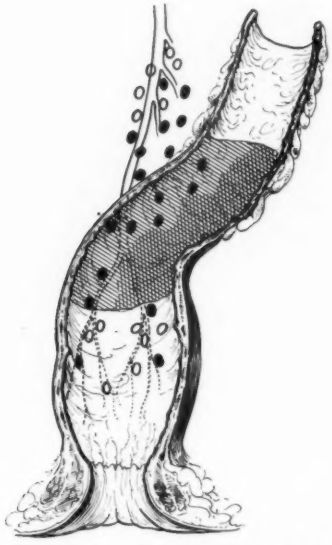

Fig. 5. Case 3. For explanation see legend of Figure 2. Compare with Figure 4.

negative results except for a large, encircling lesion especially prominent on the posterior wall high in the rectum. This lesion was verified by proctoscopic examination. On May 1, 1934, one stage combined abdominoperineal resection was performed. At operation the liver was noted as clear. The patient was dismissed from the clinic on May 24, 1934, after an uncomplicated recovery. The last report indicated death in December, 1935, with extensive metastasis about the colonic stoma, abdomen, and liver. Grossly the surgical specimen contained a huge, ulcerative lesion 15 centimeters in diameter, mucosal measurement, 10 centimeters above the pectinate line. A total of 55 nodes were found. Microscopically the lesion was a colloid adenocarcinoma, grade 4 (Broders). For distribution and involvement of nodes see Figure 3. The lowest involved node was found between 1 and 2 centimeters below the lower mucosal edge of the lesion.

Case 3. A white man, 50 years of age, registered at the clinic July 22, 1936, with a chief complaint of "bloody diarrhea." For 1 year he had had bloody rectal discharge and dull abdominal cramps with 2 final weeks of constant pain and constipation. He had lost 40 pounds (18.1 kgm.). Physical examination revealed a huge, hard, irregular cauliflower-like mass in the rectum which was verified by proctoscopic examination. On July 27 and August 24, 1936, two stage combined abdominoperineal resection was performed. The liver was clear but there was extensive spread to the bladder and around the left ureter. The patient left the clinic on September 12, 1936, without dismissal but recovery had been uncomplicated. The last report indicated death in April, 1937, but no details were given. Grossly the surgical specimen contained an extensive, annular, ulcerative lesion 9 by 8 by 5 centimeters, mucosal measurement, 6 centimeters above the pectinate line. Thirty-two nodes only were removed and examined; the others were allowed to remain *in situ* for photographic evidence as shown in Figure 4. Microscopically the lesion was an adenocarcinoma, grade 2. For distribution and involvement of nodes see Figure 5. The lowest involved node was found between 2 and 3 centimeters below the lower mucosal edge of the lesion.

Case 4. A white woman, 30 years of age, registered at the clinic August 22, 1938, with a chief complaint of "diarrhea." For 3 months she had had colicky pains in the left lower quadrant, associated with diarrhea, occasionally bloody. She had lost 13 pounds (5.9 kgm.). Physical examination gave negative results except for a "mass with some fixation of the bowel" on rectal examination. Proctoscopically a lesion was found involving the right and anterior walls of the lower part of the sigmoid colon. On August 29 and October 3, 1938, two stage combined abdominoperineal resection was performed. The liver was noted as clear but there were implants throughout the pelvic peritoneum. The patient was dismissed from the clinic November 19, 1938, in good condition after a mild postoperative urinary infection. The last report indicated death on April 7, 1941, from a recurrence. Grossly the surgical

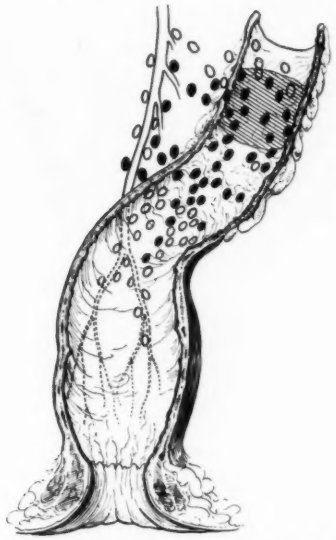

Fig. 6. Case 4. For explanation see legend of Figure 2.

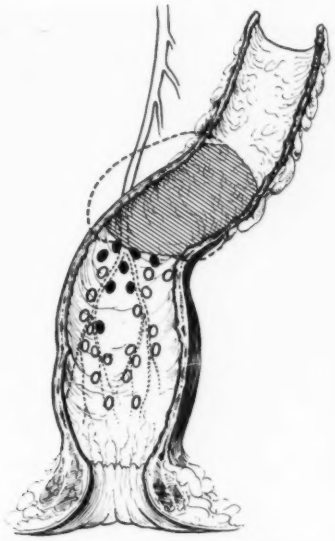

Fig. 7. Case 5. For explanation see legend of Figure 2. Compare with Figure 8.

specimen contained a perforated, annular, ulcerative lesion 4 by 3 by 3 centimeters, mucosal measurement, 16 centimeters above the pectinate line. A total of 84 nodes were found. Microscopically the lesion was an adenocarcinoma, grade 3 (Broders). For distribution and involvement of nodes see Figure 6. The lowest involved node was found between 6 and 7 centimeters below the lower mucosal edge of the lesion.

The question arises in this particular case whether all the involved nodes shown below the lesion in Figure 6 represent true *retrograde* spread. As the lesion itself was in the lower part of the sigmoid, a portion of the colon still maintaining a mesentery, it seems probable that normal flow of lymph had occurred over the two lower rectosigmoid arcades, both of which lie below the lesion. This is consistent with the lymphatic drainage of the colon proper, which differs from rectal drainage in that it may proceed along the axis of the bowel in either direction from a lesion until a vascular arcade has been reached, at which point it courses in through the mesentery to large midline plexuses of nodes. In that event only the four lower carcinomatous nodes, a span of about 3 centimeters, would represent true retrograde involvement. However, as the original premise and conditions of study included all nodes below the level of the lesion, all the nodes in Figure 6 will be considered as examples of retrograde spread.

CASE 5. A white woman, 57 years of age, registered at the clinic November 13, 1939, with a chief complaint of "increasing constipation" of 8 months' duration, bloody stools and the continual sensation of a full rectum. She had lost 17 pounds (7.7 kgm.). Physical examination gave negative results except for a "large rectal mass," which was confirmed by proctoscopic examination. On November 17, 1939, and January 19, 1940, two stage combined abdomin-

Fig. 8. Case 5. Lesion from serosal surface. Because of the absolutely solid nature of the infiltrating carcinoma in the perirectal fat it was deemed unnecessary to attempt dissection of the nodes behind and above the lesion in this case.

Fig. 9. Case 6. Lesion from serosal surface split and laid open, showing the solid nature of the infiltrating cancer (see report of Case 6).

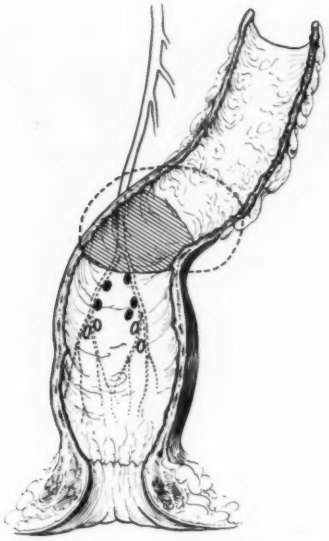

Fig. 10. Case 6. For explanation see legend of Figure 2. Compare with Figure 9.

operineal resection was performed. The liver was noted as clear. The patient was dismissed from the clinic March 18, 1940, in good condition after a complicating postoperative thrombophlebitis. The last report indicated death on April 12, 1941, from a recurrence. Grossly the surgical specimen contained a large, annular, ulcerative lesion 7 by 6 by 5 centimeters, mucosal measurement, 9 centimeters above the pectinate line, with two polyps, one 5 centimeters below the growth and one 1 centimeter above it. Twenty-seven nodes only were removed and examined; the others were allowed to remain *in situ* for photographic evidence as shown in Figure 8. Microscopically the lesion was a colloid adenocarcinoma, grade 2 (Broders). For distribution and involvement of nodes see Figure 7. The lowest involved node was found 3 to 4 centimeters below the lower mucosal edge of the lesion.

Case 6. A white man, 52 years of age, registered at the clinic December 2, 1940, with a chief complaint of "weight loss." For 3 months he had had rectal bleeding, urgency, and bouts of diarrhea and constipation. He had lost 17 pounds (7.7 kgm.). Physical examination revealed a "mass felt high in the rectum," which was confirmed by proctoscopic examination. On December 7, 1940, one stage combined abdominoperineal resection was performed. The liver was clear to palpation. The patient was dismissed from the clinic January 2, 1941, in good condition. The last report on June 18, 1941, stated that he suffered from backache and pain down both legs. There has been no further communication. Grossly the surgical specimen contained an ulcerative lesion 5 by 4 centimeters with direct extension into perirectal tissues forming a mass 8 by 6 centimeters. The lesion was 8 centimeters above the pectinate line. Only 9 nodes were removed and examined, the others being allowed to remain *in situ* for photographic evidence, as shown in Figure 9. Because of the absolutely solid nature of the infiltrating cancer throughout all perirectal tissues behind and above the lesion it was not considered necessary to isolate nodes in order to demonstrate their blocked nature. Figure 9 demonstrates adequately the large dam-like mass extending around the bowel and effectively shunting advancing carcinoma in a retrograde direction. Microscopically the lesion was an adenocarcinoma, grade 3 (Broders). For distribution and involvement of nodes see Figure 10. The lowest involved node was found 1 to 2 centimeters below the lower mucosal edge of the lesion.

Case 7. A white woman, 52 years of age, registered at the clinic June 6, 1941, with a chief complaint of "bloody diarrhea" of 5 months with spells of low backache. She had not lost weight. Physical examination demonstrated a large, nodular mass on the left posterior wall of the rectum, which was confirmed by proctoscopic examination. On June 10 and August 8, 1941, two stage combined abdominoperineal resection was performed. On September 15, 1941, the patient was dismissed in good condition after complicating thrombophlebitis, pulmonary embolism and pneumonia between stages of the resection. September 10, 1942, a plastic operation was performed on the colonic stoma. From September,

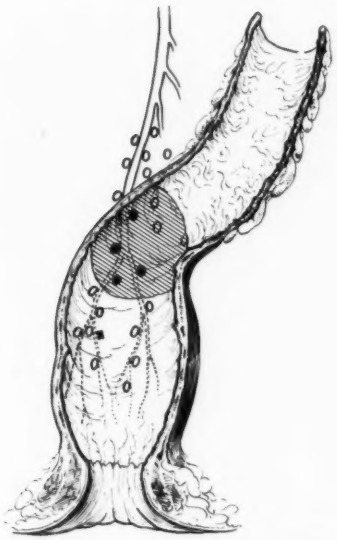

Fig. 11. Case 7. For explanation see legend of Figure 2. Compare with Figure 12. The small black rectangle is discussed in the report of Case 7.

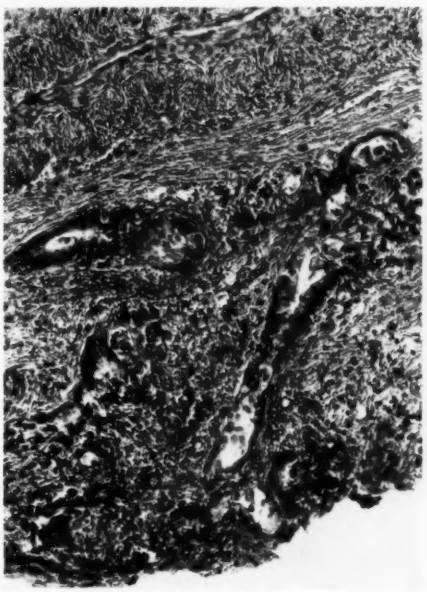

Fig. 12. Case 7. Possible perivascular lymphatic spread as discussed in report of Case 7. The vessel is cut longitudinally, the lumen appearing as a strand of cells in the upper right corner. ×100.

1942, to April, 1943, four courses of roentgen therapy were given. The last report on September 23, 1943, showed the presence of some pelvic pain. Grossly the surgical specimen contained an annular, ulcerative, perforating lesion 5 by 4 by 1.5 centimeters, mucosal measurement, 8 centimeters above the pectinate line. A total of 23 nodes were found. The small black rectangle shown on Figure 11 between 1 and 2 centimeters below the growth represents tissue removed under the impression that it was a lymph node. Careful microscopic examination indicated that very little lymphoid tissue could be identified. There was, however, a small blood vessel with a small region of carcinomatous cells immediately adjacent, which may have represented a tiny node completely replaced by cancer or may have been a rare demonstration of perivascular spread (Fig. 12). In any event it was impossible to show adequate evidence of a block above this lesion as only 4 of the 14 nodes behind and above the lesion were involved. Microscopically the lesion was an adenocarcinoma grade 1 (Broders). For distribution and involvement of nodes see Figure 11. No involved nodes were found below the lower mucosal edge of the lesion.

Case 8. A white man, 62 years of age, registered at the clinic September 8, 1941, with a chief complaint of "alternate constipation and diarrhea." One year of constipation, rectal bleeding, painful movements and a loss of 12 pounds (5.4 kgm.) were the main symptoms. Physical examination disclosed a high, fixed lesion in the rectum, which was verified by proctoscopic examination. On September 25 and October 27, 1941, two stage combined abdominoperineal resection was performed. The liver was clear. The patient was dismissed on December 4, 1941, in good condition despite a mild urinary infection (postoperative). The last report on July 16, 1943, indicated a loss of 15 pounds (6.8 kgm.) but no other evidence of recurrence. Grossly the surgical specimen contained an annular, ulcerative perforating lesion 7 by 6 centimeters, mucosal measurement, 12 centimeters above the pectinate line. A total of 56 nodes were found. Microscopically the lesion was an adenocarcinoma, grade 4 (Broders). For distribution and involvement of nodes see Figure 13. The lowest involved node was found between 1 and 2 centimeters below the lower mucosal edge of the lesion.

Case 9. A white woman, 39 years of age, registered at the clinic September 17, 1942, with a chief complaint of "constipation." For 2 years she had had recurrent rectal bleeding, pain high in the rectum and increasing constipation. She had lost 8 pounds (3.6 kgm.). Physical examination revealed a palpable mass high in the rectum, which was confirmed by proctoscopic examination. On September 23, 1942, one stage combined abdominoperineal resection was performed. The liver was clear. On October 16, 1942, a course of roentgen therapy was given. The patient was dismissed October 20, 1942, in good

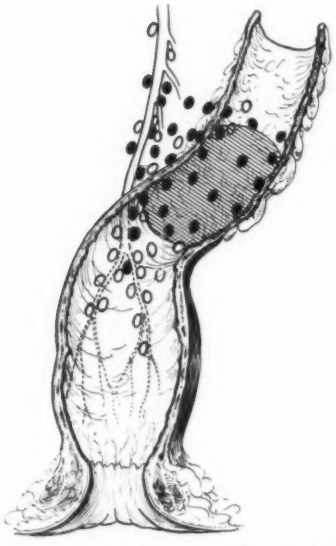

Fig. 13. Case 8. For explanation see legend of Figure 2.

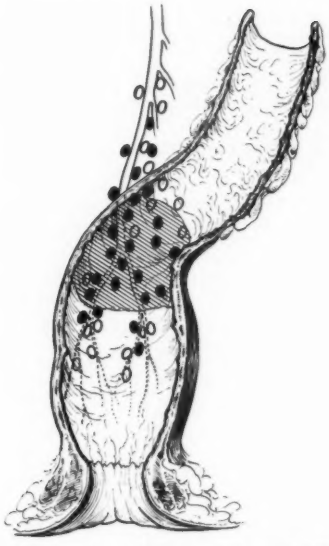

Fig. 14. Case 9. For explanation see legend of Figure 2.

condition after a mild urinary infection. The last report was on September 6, 1943, when a check-up at the clinic revealed no evidence of recurrence. Grossly the surgical specimen contained an annular, ulcerative, lesion 5 by 4 by 2 centimeters, mucosal measurement, 7 centimeters above the pectinate line. A total of 44 nodes were found. Microscopically the lesion was an adenocarcinoma, grade 4 (Broders), with squamous-cell metaplasia. For distribution and involvement of nodes see Figure 14. The lowest involved node was found between 1 and 2 centimeters below the lower mucosal edge of the lesion.

SUMMARY OF REPORT OF CASES

Nine cases of carcinoma of the rectosigmoid demonstrating possible retrograde spread have been presented in detail with all pertinent clinical, surgical, and pathologic data. In 5 cases all the nodes on the specimens were examined microscopically and in each case approximately two thirds of the nodes found behind and above the lesion were so completely clogged with cancer cells that any further drainage of lymph through their sinuses seemed impossible (Cases 1, 2, 4, 8, 9). In 1 case, only a portion of the lymph nodes were examined. More than three quarters of these nodes found behind and above the lesion were completely involved with carcinoma and photographic evidence was sufficient to show that all other nodes were likewise involved (Case 3). In 2 cases the tissues were so extensively "frozen" in cancer that it was deemed unnecessary to show any further evidence of their complete involvement than that demonstrated photographically (Cases 5 and 6). Case 7 remains an enigma. Whether the retrograde spread demonstrated in this specimen represented an involved node or was a rare instance of perivascular lymphatic permeation is unanswerable. In any event there was not the high percentage of nodal involvement behind and above the lesion considered to be necessary to form a block to the upward flow of lymph.

It may thus be concluded that, when retrograde lymphatic spread down the course of the rectum and its ensheathing structures occurs, it does so as the direct result of a block occurring somewhere across its upward channels and that the contained lymph stream is merely seeking the course of least resistance, all normal upward avenues for drainage being closed.

COMMENT

For confirmation of the mass of evidence *against* any normal retrograde dissemination

of neoplastic cells from malignant growths in the upper part of the rectum and above presented in the preceding pages, it is interesting to refer to the pathologic data which have thus far accumulated in the literature. Table I represents a complete summary of such data.

In more than 239 of the 507 cases from the literature in which the removed tissues were completely examined, nodal metastasis was observed to occur. Of these only 8 gave evidence of an involved node below the level of the lesion itself. As the lower level of the lesion was not defined in each case, the actual distance of these nodes from the lesion can only be conjectured. Nevertheless, in 7 of the 8 cases there was no spread below the 2 centimeter level, which when interpreted in the terms outlined in this study remains insignificant. One case, therefore, that of Gilchrist and David in which the involved node was 4 centimeters below the lesion, represents the total significant retrograde lymphatic flow from carcinoma of the rectum contained to date in the literature. When combined with results given previously for our cases, only a fraction over 1 per cent of far advanced malignant growths of the pelvic colon may be expected to metastasize in a retrograde fashion. If this obtains so rarely in cases in which the patient is already doomed to early demise because of the advanced nature of the lesion, one may be justified in making the statement that retrograde lymphatic metastasis never occurs from growths still in the stage of reasonable operability.

Perusal of Table I will further demonstrate that about a half of all neoplastic growths of the rectum when seen at operation do not as yet have nodal involvement. To be certain that this was true over the years from which the cases in this study were drawn, Table III was constructed. There it will be noted that in 59 per cent of the cases there was no nodal involvement. To be sure, had all these cases shown from 1916 to 1942, inclusive, been subjected to intensive study, no doubt the 59 per cent would drop below 50 per cent, as recent published studies in which the data were so treated indicate (8, 16). However, the 1 per cent incidence of retrograde lymphatic spread in advanced cases when adjusted to include

TABLE III.—NODAL INVOLVEMENT IN CARCINOMA OF THE UPPER PART OF THE RECTUM, RECTOSIGMOID AND SIGMOID: CASES IN WHICH THE LESION WAS RESECTED AND GRADED (1916-1942 INCLUSIVE)

	Total		Grades 1 and 2 (Broders)		Grades 3 and 4 (Broders)	
Nodes	Number	Per cent	Number	Per cent	Number	Per cent
Positive	910	41	679	37	231	65
Negative	1,296	59	1,169	63	127	35
Total	2,206	100	1,848	100	358	100

the average type of carcinoma occurring in the rectum (approximately 50 per cent with nodes uninvolved) then drops to less than 0.5 per cent and as such becomes negligible. Should it not be possible, therefore, in the light of pathologic evidence and in view of the many recent advances in colonic surgery, to preserve the lower part of the rectum in a very considerable number of cases in which the patients heretofore have been deprived of normal sphincteric control (10)? Perhaps time alone will provide the answer but certain it is that such attempts are more than justified and should engage the attention of all surgeons who endeavor to relieve the encumbrances of rectal neoplasms.

CONCLUSIONS

The following significant features deserve a word of emphasis in conclusion:

1. Because carcinoma of the rectum is primarily of a low grade of malignancy, the disease tends to remain localized for a considerable period and thus lends itself admirably to surgical attack.

2. As carcinoma of the upper part of the rectum and the rectosigmoid has only one normal channel for lymphatic spread—upward—provided local growth by direct extension has not incorporated neighboring organs, it should be suitable for radical segmental resection with preservation of the rectal sphincter and restoration of the normal continuity of the bowel.

3. Radical segmental resection implies the removal of a wide section of bowel together with its complete node-bearing region just as the abdominal portion of a combined abdomi-

noperineal resection is now performed (technique to be reported).

4. Section of the bowel must be at least 2 centimeters below the lower palpable edge of the lesion to satisfy pathologic requirements. The technical requirements in the successful performance of an adequate anastomosis in this area also involve the removal of such an amount of tissue because of the size and position of neoplasms so located.

5. It has been demonstrated that even in far advanced cases of carcinoma in this region, retrograde spread along the course of the bowel occurs to any degree in only 1 per cent.

6. When such retrograde spread can be demonstrated, it is an indication that upward normal channels have been blocked.

7. When these facts become more generally appreciated and the technical procedures required for such surgery are subjected to refinement, many sufferers from neoplastic lesions in the rectosigmoid region will enjoy a normal postoperative existence without the psychologic—to say nothing of the anatomic—detriments of a permanent artificial anus.

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RECTAL STRICTURES DUE TO LYMPHOGRANULOMA VENEREUM

With Especial Reference to Pauchet's Excision Operation

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DESPITE the abundant and ever increasing literature on the general subject of lymphogranuloma venereum, surgeons still differ greatly in their opinions as to the best method of treatment of lymphogranulomatous strictures of the rectum. The use of sulfonamides, and more recently of penicillin, has lessened secondary infection in these cases, but in no way has it decreased, in certain cases, the tendency of the disease to progress and develop fibrous tissue that cicatrizes and produces marked rectal stenosis.

An example of such a patient is presented through the courtesy of Dr. Marshall E. Ross, of the gynecological service, with whom one of us (L. T. W.) examined the patient in consultation.

S. D., colored widow, 45 years of age, a domestic, was seen August 7, 1937. She complained of a swelling about the vulva, which began as a small pimple 18 years before, gradually grew larger, and was painless. In 1935 because of constipation and pain on defecation she was treated elsewhere with deep x-ray therapy. The vulval swelling immediately increased in size, she had lost weight, was easily fatigued, and had pain in the perineum. The Frei test was strongly positive and a biopsy of tissue from the vulval swelling, which also involved the anus, showed marked fibrosis with round cell infiltration and some plasma cells. Examination on consultation in August, 1937, revealed elephantiasis of the vulva involving the anus, a stricture of the vagina, a rectovaginal fistula and a marked annular stricture of the rectum 1 centimeter above the internal sphincter. She was advised to have a colostomy operation but refused. She subsequently moved to Connecticut, and in reply to a follow-up letter her physician wrote under date of November 28, 1938, as follows:

"... when first examined she had large sloughing pedunculated granulomatous ulcerated overgrowths involving the labia majora and minora extending from the pubis in front and including the rectal sphincter behind. The rectal sphincter had been entirely destroyed and the septum between the vagina and the lower rectum was destroyed.

"... a complete excision of the growth from the pubes to the coccyx was done and the wound was closed except for drainage at the angles. For about 2 weeks she did very well and then the wound broke open somewhat leaving a granulating surface, which was skin grafted. The skin graft took for the most part. She left the hospital and was up and around feeling fairly comfortable.

"But the wound gradually broke down and signs of intestinal obstruction developed. Stricture ever narrowing could be felt at the junction of the rectum and sigmoid. As it seemed evident that the infection still persisted in the lower rectum and around the stricture and in the pelvis where a large mass could be felt it was decided to do a laparotomy. At laparotomy a large dermoid growth of the right ovary the size of a grapefruit was found. This growth was removed and in addition a hysterectomy, double salpingo-oophorectomy and colostomy were done bringing the sigmoid out through a stab wound in the left flank. A resection of the lower segment of the sigmoid and rectum including the stricture was also done ... The patient withstood the ordeal remarkably well. She recovered and went home. Later she returned and at that time she had developed squamous cell carcinoma at the left edge of the vagina at the junction of the vaginal mucosa and skin. Radium needles were inserted in this growth and the cancer disappeared ... and again she returned to her home.

"She returned in a few weeks with a crater about 2 inches deep burrowing into the left upper leg toward the femoral artery and the left side of the vagina was involved in this crater. Numerous sinuses discharged pus which oozed from openings throughout the floor of the crater so that as it was impossible to incise all these to give adequate drainage, the whole crater was coagulated. When the slough was removed the crater looked quite healthy and was healing satisfactorily but the patient became increasingly thin and emaciated and died. ... Autopsy was refused so the real cause of death was not determined although it would seem that it was probably caused by urinary involvement from extension up along the ureters.

From the Surgical Service of the Harlem Hospital, Dr. Louis T. Wright, director.

Founders' lecture. Medicochirurgical Society of the District of Columbia, November 15, 1945.

". . . The Frei antigen was continued here for some time and in addition two courses of sulfanilamide and antisyphilitic therapy for weeks were given. Before I saw her deep x-ray therapy had been applied to the lesion. It was my opinion that the lesion might be cured by wide excision of the affected area and this is still my opinion. It was my belief that operation had been radical enough but apparently some of the disease was left behind and gradually progressed."

This case illustrates the progressive nature of the disease, its seriousness, the later development of carcinoma with a fatal termination despite all known methods of treatment, including an abdominoperineal resection, which here was obviously performed too late to be of value.

HISTORICAL REVIEW

It seemed worth while, therefore, to review briefly the historical background of the disease and excision procedures and to report 26 personal cases in which we have resected the rectum preserving the anal sphincter.

Lymphogranuloma venereum was isolated in 1913 as a separate clinical entity by Nicholas, Favre, and Durand. Frei (6) greatly advanced interest in the disease when he introduced his intradermal diagnostic text, which has proved to be specific. Hellerstrom showed that lymphogranuloma venereum was due to a filterable virus. Frei and Koppel (8) and Bensaude and Lambling proved that the majority of non-neoplastic strictures of the rectum were due to this disease.

Larsen, in 1849, described inflammatory strictures of the rectum in 11 women.

The first case of excision of the rectum for stricture was reported in 1864 by Glaser. His patient had a recurrence and 2 years later he had to make a colostomy. During the next 20 years several surgeons reported a few additional cases, but because the operation was difficult and there were recurrences, the operation was discarded.

To Professor Henri Hartmann (10), of Paris, goes the credit for recognizing the seriousness of the disease and giving it careful and prolonged study in all of its surgical aspects. Early in his career Hartmann performed 16 external rectotomy operations. In no case did it cure the patient, but it relieved them, and all of them continued to suppurate and suffer a certain degree of incontinence. For this reason he gave up the operation. Later, in 1895, Hartmann and Quenu (23) reported a series of 35 cases, most of them their own, in which an excision of the stricture was done; they concluded that the operation of excision "seemed to tend toward ultimate recovery." Since then, for a period of approximately 40 years, Hartmann has advocated resection and has successfully performed the operation in many strictures of the rectum. Careful histopathological studies were made of each resected specimen. In 1930, he reported excision operations upon 66 patients for rectal stricture. An abdominoperineal amputation was made in 6 cases and 3 patients died, a mortality of 50 per cent. At first the perineal amputation was made without considering the sphincters and in 56 cases the results were only fair. One of 9 such patients died. Only 4 patients could be followed and 2 of them were cured. The best results were made by intrasphincteric amputation, and he stated: "Real cures can be obtained in most strictures not accompanied by profuse suppuration." Among 27 such amputations there were only 2 deaths, and he states:

"It was possible to follow 31 of the patients. There was a recurrence of the stenosis in 3 cases and a colostomy was necessary in 1 year, 4 years, and 6 years after amputation. Eight patients were improved but continued to suppurate and one of them died at the end of 13 years with diarrhea and swelling of the face, probably due to amyloid degeneration. Twenty patients were cured of their rectitis and there was no stenosis or separation of the mucosa. An endoscopic examination of the rectum showed that the mucosa was normal in appearance. All of these patients were continent, but the continence was not absolute and when they had diarrhea they were not able completely to retain their feces. Two of the patients complained of having moisture around the anus."

In Hartmann's *Chirurgie du Rectum*, published in 1931, he has an extensive chapter entitled "Rectites Stenosantes" which includes his experiences and many detailed case histories, and he concludes:

"The first thing, in contradiction with the recognized opinion, is that excision of the rectal stenosis may give complete and definite recovery." Colostomy "indicated from the first, when the rectitis

is abundant with suppuration, and complicated with multiple fistulas, ameliorates the state of the patient considerably and makes life bearable. It may be wholly insufficient if the suppuration continues abundantly and, above all, if hemorrhages take place."

In 1926, De Roche reported 21 cases of fibrous strictures of the rectum in which resection was done with one operative death. Follow-up results were obtained in 8 cases, which were as follows: after 1 year, 1 suppurated, 1 had to be dilated, 3 had relapsed, and 3 had maintained excellent results.

Dimitriu and Stoia, in 1933, reported 25 cases of abdominoendoanal excision with preservation of the sphincter mechanism. Nineteen patients were cured, 3 died, and 3 recurred.

It seems that French surgeons were the first to recognize the essential need for surgical treatment of serious strictures of this type. The surgical treatment aimed at: (1) correction of the stenosis, and (2) extirpation of all diseased tissue to prevent spread.

Lockhart-Mummery, who represents the best English opinion, in his textbook in 1934, states:

"If a stricture is noted near the anus, very excellent results in suitable cases are obtained. A modification of Whitehead's operation is all that is necessary to get rid of the stricture. It is not easy, as a fibrous tissue outside the stricture prevents the separation of the mucosal membrane in the normal manner and this renders it difficult. When the stricture is more than one inch from the anus, the method is not possible and a formal excision similar to that for malignant disease is necessary. The operation of excision of a portion of the rectum for nonmalignant stricture is not one to be lightly undertaken, as a stricture serious enough to warrant removal of this portion is almost certain to be associated with a dense amount of fibrous tissue in the surrounding parts, which makes the anatomy quite abnormal, and may cause great difficulty in separation of the rectum."

In none of his published works has Lockhart-Mummery shown any enthusiasm for the excision operation as a method of treatment for rectal strictures.

Martin, in 1933, reported a series of 227 rectal strictures in negro women, and concluded that the disease is incurable and tends toward an inevitable fatal termination, but nowhere does he suggest a definite method of treatment. Spiesman, Levy, and Brotman, in a study of 183 strictures from the Cook County Hospital, reported 2 resections, one done by Davison and one by McNealy.

Edwards and Kindell reported satisfactory results in 6 cases in which they made a preliminary colostomy, and later did a perineal extirpation of the diseased rectum according to the technique described by Lockhart-Mummery for rectal malignancy.

Barber and Murphy from Bellevue Hospital reported 35 cases of resection; 4 were one stage sacroperineal and 31 were abdominal colostomies followed by sacroperineal resections. Five of their 35 patients died, which gave a hospital mortality of 14.3 per cent. These 5 were extreme cases and there were no immediate postoperative deaths. They stated that in 2 patients who had had an original colostomy the colostomy ceased to function after the granulomatous process crept up to, and involved, the sigmoidostomy stoma. They made a permanent abdominal anus in their advanced cases. Two cases showed carcinoma.

Woods and Hanlon, in 1944, reported from the Cincinnati General Hospital 35 cases treated by rectosigmoid resection. In analyzing 192 cases of rectal stricture, they stated that "colostomy has been usually employed at an advanced stage, with no constant success in arresting the disease." They performed colostomy without resection in 34 cases; 2 died of postoperative complications; radical resection was performed in 35 cases. With no operative deaths, abdominoperineal resection was performed 23 times with good results in 20 of the 23 cases. In the perineal resection of the Lockhart-Mummery type in 9 cases the results were good in 5, poor in 2, and fair in 2. They emphasize, however, that the resection operation is a procedure of considerable magnitude and should be undertaken only after conservative methods fail. They conclude, though, that the abdominoperineal resection is a satisfactory operation and that they have never seen resolution of firm fibrous strictures.

From the above résumé and from a study of other available literature, it becomes apparent that the general attitude in this country and in England, up until about 5 years ago, was

that these cases were best treated by dilatation, if the lesion was apparently mild, and by a permanent colostomy, if the patient's condition was at all serious. Only in the reports from the Baltimore City Hospital by Edwards and Kindell, from the Bellevue Hospital by Barber and Murphy, and from the Cincinnati General Hospital by Woods and Hanlon, have American surgeons shown any indication of their appreciation of the definitive treatment of this serious malady.

Our own experience coincides with that of Hartmann, namely, that drugs, dilatation, and other simple procedures can in no way take the place of radical surgery in the treatment of advanced rectal strictures. The increased tendency on the part of some American surgeons to use excision as an operation of choice indicates their recognition of this fact.

At Harlem Hospital we have had 4 deaths following dilatation of rectal stricture, while Woods and Hanlon report 7 deaths following the same procedure at the Cincinnati General Hospital. There is no doubt that many deaths as a result of bougie or instrumental dilatation of benign strictures of the rectum have occurred throughout the country but the cause of death has not been so reported.

Liccione was the first to report carcinoma as a sequela of rectal stricture; he recorded 2 cases. Woods and Hanlon reported 3 cases, and 3 cases were reported by Barber and Murphy from the Bellevue Hospital. We found records of 3 cases in the hospital and one of us (L. T. W.) observed another case in private. It is noteworthy, therefore, that the incidence of a superimposed carcinoma of the rectum upon this apparently benign lesion occurs much more frequently than is supposed.

We have used, in the treatment of these strictures, every form of mild treatment excepting x-ray, and this includes finger dilatation, dilatation with Wales bougies, posterior proctotomy in some instances, in rare cases Keller's tunnel grafts, sulfonamides, Frei antigen, diathermy, carbon dioxide snow; none of these availed but little in the serious cases. We have found that posterior proctotomy operations, followed by bouginage, give temporary relief, but that in the final analysis they serve only to spread the disease and to make the stricture more rigid. Levy, Holder, and Bullowa, from our out-patient department, reported good results with sodium sulfanilyl sulfanilate, but the end-results have not been up to expectations; in fact, some of the patients so treated are still coming back to the clinic and no doubt others have wandered off to other hospitals.

Many of the unconsidered factors in the difficulties of the palliative methods of treatment of strictures, particularly in colored people, are due probably to the fact that certain fibrous tissue reactions, such as keloids and elephantiasis, are predominant in colored races. Rosser used this observation to explain the frequency of rectal strictures in negroes and postulated that they had a tendency toward fibroblastic tissue hypertrophy. This has been our experience.

Colostomy has been the ultimate procedure used in most clinics when the patient's life is obviously threatened. Many colostomies have been performed by us for relief of benign rectal strictures in females. Seven patients entered the hospital with colostomies done elsewhere; 5 patients showed a stricture of the colostomy opening after operation; 4 patients needed another colostomy. Some authors have claimed that colostomy alone tended to cure or soften the strictures. This is, of course, absurd. It is true that ulceration, secondary infection and toxemia resulting therefrom have been lessened by diversion of the fecal stream, but we have never found that colostomy cured a real fibrous stricture of the rectum.

Experienced surgeons know that colostomy *per se* is not without certain specific dangers. This is true even when performed by surgeons of ability and great experience. These dangers are first, stenosis or a stricture of the colostomy opening. Such stricture occurs a few months or a few years after the artificial anus has been made. It happened in 5 of our cases and in 2 patients admitted from other hospitals. The second danger is retrograde or anteriorgrade herniation of the bowel. This herniation occurs when the opening in the abdominal wall is too large. If the proximal segment of the bowel is mobile, an anteriorgrade herniation occurs. This occurred in 4 of

our cases. If the distal end of the sigmoid is mobile, a retrograde herniation occurs; this happened in 3 of our cases and in 2 patients admitted from other hospitals. It is impossible to foretell whether any of the above complications will or will not occur following a colostomy. We have seen secondary operations performed and deaths occur because of all of the above complications. Therefore, it is our conclusion, that colostomy, although successful in some instances, is not and cannot be the best surgical answer to this problem. At best, it can serve only as a definitive method of treatment when no other rational option is available. Aside from the surgical complications, many patients will go on to their deaths and refuse help rather than have an artificial anus, and particularly is this true in young women in the early decades of life. It is likewise true that when the disease involves the entire rectum or extends up to the sigmoid, one has no choice but to advise a permanent colostomy with or without a sacroperineal resection; otherwise the patient unquestionably dies.

We have seen patients with dangerous and serious sequelae which followed colostomy operations, even in the hands of experts. When there was marked stenosis of the colostomy opening—and these cases are numerous in colored people—we have had to perform another colostomy in the transverse colon. Many strictured colostomy openings develop abscesses and fistulas. We have also had to treat some of the so called perineal resections done at other hospitals for serious late infection, which, in one instance, extended up to the fifth dorsal vertebra (Figs. 1 and 2).

The seriousness of this disease is further emphasized by Kassebohm and Schreiber who have reported from the Obstetrical Service of Harlem Hospital deaths due to the rupture of the rectum during spontaneous delivery and instrumental delivery and they consider it a very serious complication of pregnancy; in fact, they recommend either therapeutic abortion, if recognized early, or cesarean section, if late.

We agree totally with Hartmann that the treatment of choice of low strictures of the rectum is excision. We further believe that as our technique improves the mortality will become lower. It is also our opinion that surgeons in clinics who see large numbers of these cases will eventually come to this conclusion.

CASE REPORTS

The first patient was seen and operated on in private by one of us (L.T.W.). A brief abstract of her history follows:

C. M., colored female, married, 34 years of age, mother of one child 12 years of age, was first seen in the office in November, 1924, at which time she complained of an abscess near the rectum. She was emaciated, anemic, nervous, and weak. The only other essential point in her history was that she had had a history of having 7 operations for perirectal abscesses during the previous 5 years. Constipation, deformed stools, and at times passage of blood and mucus from the rectum completed her history. Examination revealed a stricture of the rectum which would barely admit a No. 24 F. catheter. Two fistulous openings were present on the right side of the rectum. The perineum showed perianal and periproctitic thickening. In December, 1924, posterior proctotomy with wide excision of all fistulous tracts was done. In October, 1925, left inguinal colostomy was performed. In January, 1926, the rectum was excised preserving the external sphincter mechanism according to the method of Victor Pauchet. Convalescence was slow but uneventful and complete healing of the perineal wound did not occur for a period of 2 months. This patient frankly stated that she would prefer to die rather than have a permanent artificial anus and that she would willingly undergo any risk that would offer her a chance of health. Later the colostomy was closed. In the spring of 1945, 19 years after her original resection, this patient reported that she was in excellent health.

This first patient, with several others, was demonstrated at a symposium given in 1938 by the surgical department of our hospital in honor of Dr. Wilhelm Frei. Because of the satisfactory result in this case we were stimulated to use the method, beginning in 1931, on the surgical service of Harlem Hospital, and the authors of this article constituted an indoor group for the clinical study of these cases. All of the second stage operations were performed wholly or in part by the senior author (L. T. W.)

We have used this operation in 26 cases. The following is an illustrative case referred to the senior author:

J. G., colored woman, 26 years of age, married 5 years, never pregnant, husband living and well.

History of rectal bleeding, pain during defecation with a discharge of pus and mucus from the rectum during the past 4 years. She had been hospitalized on two or three occasions for dilatation of the stricture without much permanent relief. She had been having chills and fever off and on for the past 2 years. Physical examination revealed a tight annular stricture of the rectum one-half inch above the anus which did not admit the tip of the little finger. The blood count showed 4,000,000 red blood cells, 8,000 leucocytes, 74 per cent polymorphonuclears, 26 per cent lymphocytes, 55 per cent hemoglobin. The Frei test was strongly positive. Urinalysis showed occasional white blood cells and red blood cells. Blood chemistry: creatinine 1.2, urea nitrogen 13, sugar 75. Wassermann test negative. Colostomy was performed May 11, 1936. (Fig. 3). She was discharged May 31, 1936.

She returned on October 5, 1936, for the second or excision stage of operation, which was performed on October 6. Pathological report by Dr. Solomon Weintraub: large mass of tissue 5 by 5 by 5 centimeters. The mass had an irregular nodular surface, with moderate hemorrhagic discoloration of the surface. The mass itself showed marked fatty infiltration and on cut surface had a grayish white fibrous appearance and extremely firm consistency. Microscopic diagnosis: acute and chronic inflammation of the rectum with fibrosis. She was discharged on December 6, 1936. On March 1, 1937, she returned for closure of the colostomy and was discharged May 22, 1937. Figure 4 shows the condition at the time of her discharge. In reply to a letter of inquiry, her referring physician wrote on December 14, 1943, as follows:

"I examined Mrs. G. in 1943 for some other condition. At that time she had no gastrointestinal symptoms whatsoever. Examination showed a somewhat patulous but perfectly competent anus. At the end of the examining finger, rectally, there was a slight degree of nonobstructing rectal constriction. The patient weighed 35 pounds more than she did in 1936, and she felt very well."

Examination in our follow-up clinic in February, 1944, was as follows: no trouble with the rectum since closure of the colostomy in 1937. She has full control of her bowels. On examination she showed a red linear scar in the suprapubic region from hysterectomy operation which she had on September 24, 1943, for fibroid uterus. The skin around the anal margin was soft, the mucosa red and healthy. There was no stricture or ulceration.

In the 26 cases, in which the above procedure was carried out, 2 deaths occurred in the hospital. One death occurred on the day of operation—the resident surgeon had failed to appreciate the fact that the patient was in secondary shock and needed a transfusion. Another patient died of peritonitis following closure of the colostomy by one of the associate surgeons on the staff; death, of course, was not attributable to the excision operation. We have been able to follow 12 patients, 7 to 19 years after operation and the result in 8 cases was satisfactory. One patient still had sinuses on each side of the rectum which intermittently drained a slight amount of pus; this patient showed osseous involvement and was reported as such (28). Another patient showed a slight tendency toward rectal prolapse where the mucosa had separated from the skin margin. One patient showed a stenosis at the anal margin. One patient became psychotic. It is of interest to note that in all of these patients, excepting the one with the draining sinuses, the disease was completely eradicated; also that 8 of these patients had an excellently functioning anus with control over their bowels except when they took laxatives.

TECHNIQUE

The operation was performed in three stages in 24 of the 26 cases. The following drawings—Figures 5, 6, 7, 8, 9, 10 and 11, which are after Pauchet, and No. 12, which is diagrammatic—illustrate various steps in the operation. The first stage is the making of a temporary colostomy. After the colostomy and when the general condition of the patient has improved to the point where it is felt that she can withstand a resection, an effort is then made to disinfect the distal sigmoid and rectum in so far as possible, as a preliminary to resection of the rectum. The second stage is the stage of resection and after this has healed, the third stage is to close the colostomy. The time interval between the different stages varies according to the clinical condition of the patient.

Early in our studies we used barium enamas to determine the length and extent of the strictured area, but we soon found that its use was more a disadvantage than an advantage, the reason being that, although the procedure did give us some information as to the height of the stricture, the barium often became inspissated above the stricture and was extremely difficult to remove. We later learned to investigate the extent of the stricture when the abdomen was open while we were performing the colostomy. Before any operation is

Fig. 1. Patient C. A. Appearance on admission, November 30, 1938, of an abdominoperineal resection of a stricture performed at another hospital 6 months previously on June 3, 1938. She was emaciated, weak, and dehydrated. The infection had burrowed upward along the supraspinous ligament to the level of the fifth dorsal vertebra.

undertaken, we take great pains to explain to patients that they may have to go through life with a permanent artificial anus in the event we should find at the time of the colostomy operation that the stricture extends so high that it is not resectable. This the patient understands thoroughly beforehand and agrees to, and it is also understood that if the stricture is one that will lend itself to resection, that will be done and that eventually the colostomy opening will be closed.

Fig. 3. Photograph of temporary colostomy. Patient J. G. May 31, 1936.

Fig. 2. Patient C. A. Appearance at time of discharge March 1, 1939. The entire area of infection was opened widely and packed with zinc peroxide, which resulted in healing.

Two low strictures were resected in a one-stage operation without colostomies having been previously performed (Figs. 13 and 14). In these 2 cases it was possible to resect the rectum without entering the peritoneal cavity and the healthy rectum was brought down intrasphincterically and sutured to the surrounding skin. The only trouble with this procedure, and for that reason we gave it up, is the fact that, although it cures the patients of their disease and their stricture, it also brings the cervix of the uterus down to the vaginal introitus, and to this condition the patients later objected strenuously.

In performing a colostomy for stricture of the rectum, the sigmoid and rectum are examined carefully as to the length of the stricture, the extent of infiltration of the disease, and a search is made for enlarged lymph nodes; this information is used as a basis for deciding for or against resection. In a few

Fig. 4. Patient J. G. Appearance of operative site 3 months after excision stage. Condition unchanged when examined 8 years later.

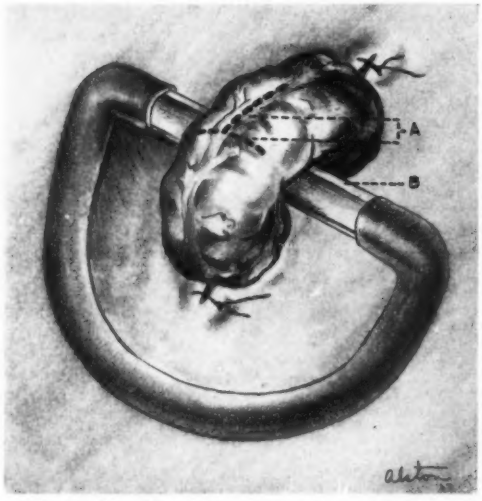

Fig. 5. Drawing of colostomy at time of opening. *A*, Lines of incision used. *B*, Glass rod or Makins' tube which holds up the loop.

Fig. 6. Anus has been closed with a suture, and the line of incision is shown (drawing after Pauchet).

cases, not included in this series, the sigmoid was found to be plastered down to the posterior abdominal wall and the rectum and sigmoid exhibited thickening of their walls and luminal narrowing, which rendered them obviously unsuitable for resection. In one patient, not included in this series, following resection, the new anus cicatrized to such a point that we were not able to close the colostomy. This patient refused further treatment because she was satisfied with the colostomy. There is, however, no evidence of active disease around the rectum. In a large number of colostomies performed by us in this disease, we have searched carefully for iliac and other glandular enlargement; this we have never found. For anemia at first we used ventriculin with iron which helped to overcome the anemia rapidly. All of these patients gave a positive Frei reaction; 20 of the 26 gave a positive Wassermann reaction.

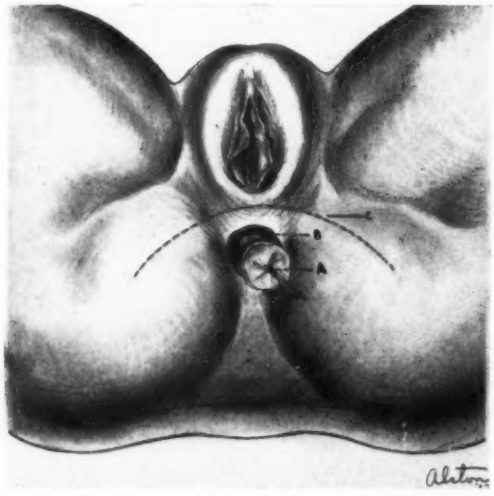

Fig. 7. *A*, Button of skin around anus. *B*, Sphincter ani muscle exposed following dissection of anal mucous membrane. *C*, Line of curvilinear incision (drawing after Pauchet).

In general, these patients at the time of the preliminary colostomy were usually emaciated, toxic, and in very poor general clinical condition. They were allowed to go home until their clinical condition improved, which was 3 or more months, after which they were brought back for the second stage of the operation, which was the excision of the rectum with preservation of the sphincter. After the latter stage, which required usually from 4 to 8 weeks to heal, the patients were allowed to go home for a few weeks, if they so desired,

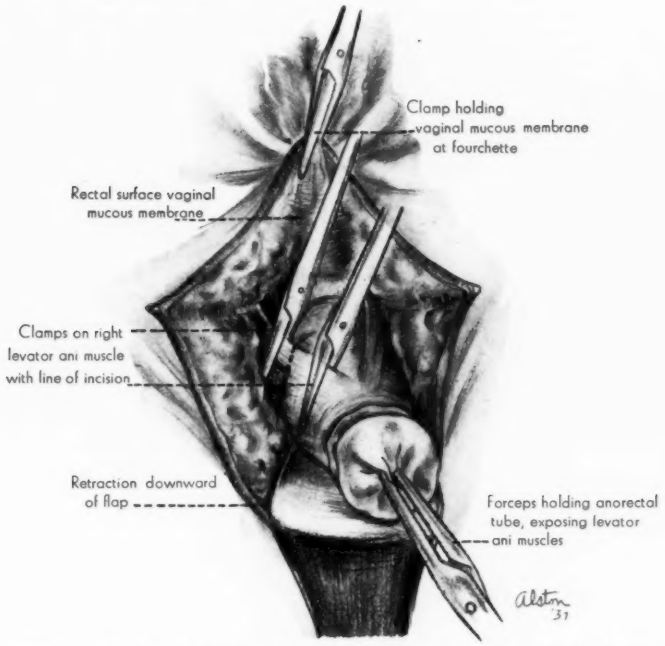

Fig. 8. The lower flap contains the sphincter ani muscle (drawing after Pauchet).

after which they would return to have the colostomy closed. It should be pointed out that these patients, because of their poor clinical condition before the colostomy and because of the magnitude of the second or excision stage, require a longer period of hospitalization than do most patients and during this time they require careful supportive treatment.

The technique used was not original with us, but we followed, in the main, the one described by Pauchet. Preliminary to the resection stage of the operation, it was our custom at first to instill thrice daily 2 ounces of a 10 per cent solution of argyrol into the distal segment so as to render it as bacteria free as possible; later we irrigated the rectum through the colostomy opening with a 1:5000 solution of zephiran. Ether anesthesia was used.

The anal sphincter is dilated fully, the anus is closed with a heavy silk suture, and an area of skin about the size of a silver dollar is dissected up exposing the external sphincter muscle. The mucous membrane lining the anal canal is freed with scissors and blunt dissection, just as in the Whitehead operation for hemorrhoids. The stricture is usually located at the junction of the rectum and the internal opening of the anal canal. A curvilinear incision is made that extends from near the tuberosity of the ischium on one side upward to the fourchette and then downward to the area over the tuberosity of the ischium on the other side. The anterior wall of the rectum is then separated from the posterior wall of the vagina. At times the rectum is unavoidably opened at this point, but where this has happened no serious infection has developed.

The levator ani muscles on each side are divided between clamps close to the rectum and ligated. At this time one cuts through much scar tissue which bleeds and oozes very freely; this hemorrhage is controlled by the frequent use of hot pads. After a partial dissection of the stricture from its surrounding

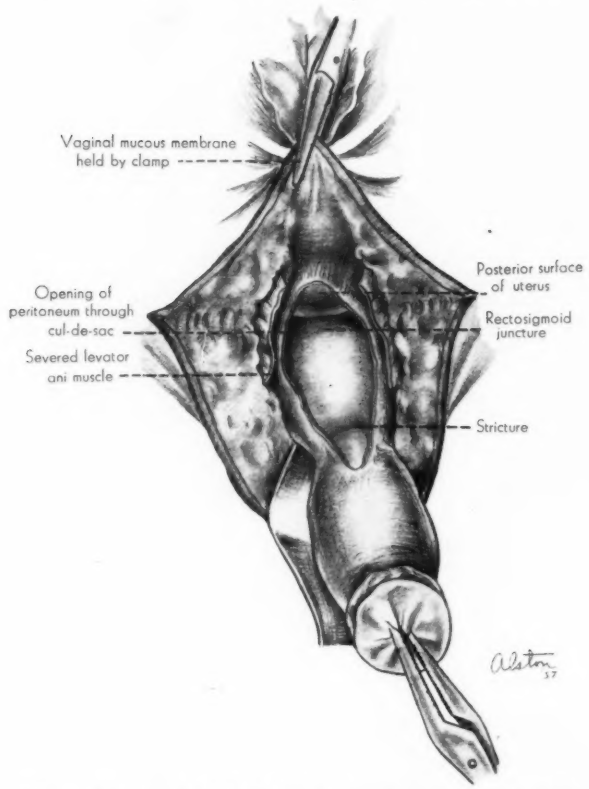

Fig. 9. The pouch of Douglas has been opened (drawing after Pauchet).

tissues, the apron of skin which carries in it the sphincter muscles is allowed to fall forward and downward. The firm rectococcygeal ligaments are divided and retractors hold the skin flap downward. The rectum is then easily freed in the hollow of the sacrum and its lateral fascial attachments above the levator ani muscles are divided.

The peritoneal cavity is entered through the pouch of Douglas. The rectum is pulled down to a point above the strictured area. The superior hemorrhoidal vessel and all other bleeding points are carefully ligated. The diseased portion of the rectum is excised at a point through healthy rectal tissue. The proximal end of the rectum is brought down intrasphincterically and its margins are sutured to the skin edges with interrupted black silk sutures which bring the rectal mucous membrane in direct contact with the skin. Two Penrose or cigarette drains are placed into the peritoneal cavity, one coming out at the lower angle of the wound on each side, as shown in the illustration (Fig. 11). A piece of vaseline gauze is placed in the new anal canal.

The patient is given a blood transfusion, 500 cubic centimeters of blood, immediately after the operation and she is watched very closely during the next 4 hours for the possible development of secondary shock. If the patient during this time goes into shock again another transfusion is given, usually 200 or 300 cubic centimeters of blood. During the same immediate postoperative period an intravenous drop of normal saline solution is given. The following day the patient's bed is placed in

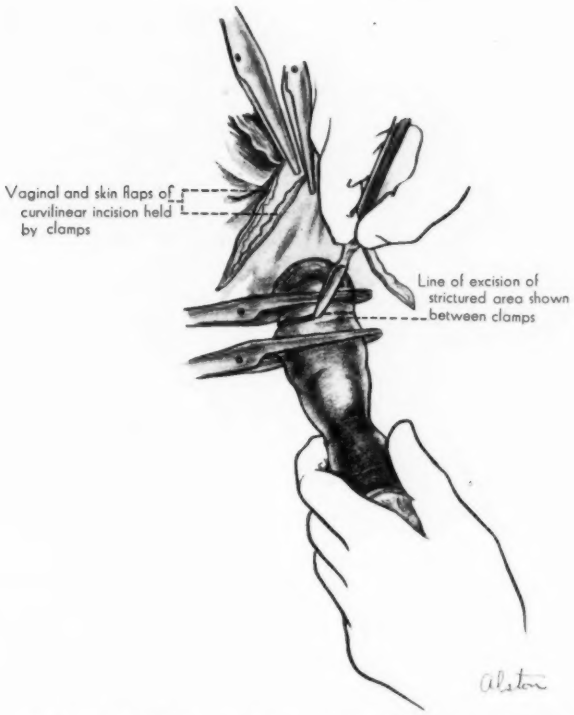
Vaginal and skin flaps of curvilinear incision held by clamps
Line of excision of strictured area shown between clamps

Fig. 10. Division of the rectum proximal to the stricture (drawing after Pauchet).

high Fowler's position. After the rectal operative site is healed, the colostomy is closed.

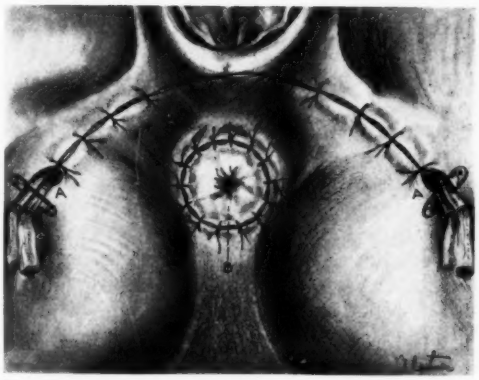

Fig. 11. *A*, Drains which extend up into the pouch of Douglas. *B*, New anal canal (drawing after Pauchet).

OBSERVATIONS

In performing the preliminary colostomy it is important to use the segment of sigmoid

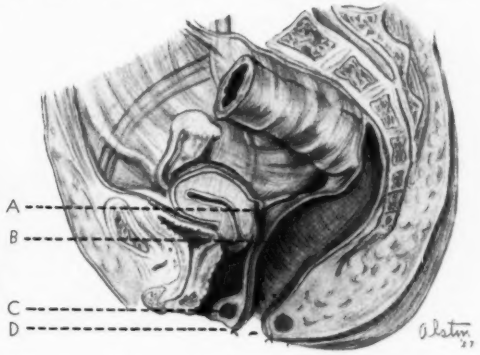

Fig. 12. Diagrammatic cross-section view at end of operation. *A*, Cut edge of peritoneum. *B*, Rectum. *C*, Sphincter ani muscle. *D*, Suture approximating mucous membrane to skin.

Fig. 13. Patient H. F. Photograph of introitus of patient who had a one stage resection 4 years previously. *A*, The cervix at the opening of the vaginal canal. This patient became pregnant and was delivered by cesarean section, 1 year after resection of the rectum. Thirteen years later, this patient has a well functioning anus but her cervix is still at the introitus which condition she has refused to have corrected.

Fig. 14. Patient N. H. Operative site 2 years after a one stage resection. No evidence of disease. Well functioning anus and rectum.

Fig. 15. Operative specimen patient C. W., age 24 years. Stricture complicated with rectovaginal fistula. First stage December 4, 1936. Second stage May 1937, at which time specimen was removed. Colostomy closed February 10, 1938.

that is at the highest point above its mobile part. This step will permit the segment to be drawn down when the rectum is resected. In one instance, this point was not observed when a colostomy was performed and, during the resection stage of the operation, after the rectum was freed and the diseased portion excised, there was not sufficient mobility to permit the bringing down of the healthy end of the rectum to the skin. This patient developed a psychosis upon learning that she would have to keep her artificial anus and she was transferred to a mental institution where she died. It is imperative that the highest mobile point of the sigmoid be the site of choice for the performance of a preliminary colostomy if the stricture is resectable. If the stricture is not resectable, the making of a colostomy at that site for a permanent artificial anus is dangerous because there may be the development, later, of a retrograde herniation in a few cases.

With the advent of the sulfonamides, particularly sulfasuxadine which has been a boon in lessening infection in the large bowel, it is possible that we may be able to do these resections in one stage and open the peritoneal cavity without danger. This we have not yet attempted. We still believe that the three

Fig. 16. Patient M. B. Anal tumor, stricture of rectum, and fibroid of uterus. Colostomy and hysterectomy May 14, 1932. Resection of tumor with stricture by dividing lower third of vagina and sphincter muscles. Closure of colostomy October 8, 1932. Follow-up 12 years later showed good results.

Fig. 17. Patient V. B. Anal condition at time of admission in 1934. Three stage operation. Well functioning anus in 1945, at which time she was on the gynecological service for a pelvic mass. No signs of anorectal disease.

stage operation of preliminary colostomy, followed by resection when the clinical condition of the patient has improved, and followed by the closing of the colostomy, is the procedure which gives the patient the greatest protection.

Sometimes these patients present tumor masses around the anus which have to be excised at the time of the second operation. Figures 16 and 17 show the external appearance in 2 cases in which resection was done and the end-results were excellent.

Dr. Milton J. Schreiber from the obstetrical service reports that he has delivered spontaneously 4 of the patients who have had excision operations in this series without any ill effects.

We have had no experience with Hartmann's method of perineal resection, the Lockhart-Mummery method of resection as used by Edwards and Kindell and Barber and Murphy, and the modification as used by Woods and Hanlon. In all of our cases we have preserved the sphincter, a point which Hartmann later conceded to be important, although his operative approach was sacral rather than the approach which was used by Pauchet.

It should be clearly understood that the operation of excision is a very serious operation and one to be used only in selected cases and by surgeons of experience. It should not be performed by the surgeon who does this type of operation only occasionally, although we are certain that as a given surgeon's operative experience with the disease grows his results will improve. It is hoped that early diagnosis and the use of chemotherapy will obviate the necessity for the use of surgery in these cases before a true rectal cicatricial stenosis has occurred.

CONCLUSIONS

1. Resection of the rectum with excision of the diseased area and preservation of the sphincter is the treatment of choice in certain selected cases of fibrous stenotic strictures of the rectum.

2. Permanent colostomy may have to be performed as an operation of necessity when the disease is so extensive that it cannot be resected with ease.

3. Abdominoperineal resection may be justified in certain cases in which the stricture extends so high that a sphincter preservation operation cannot be done.

4. Twenty-six cases in which resection of the rectum with preservation of the sphincter was performed according to Pauchet's technique are reported with 2 immediate deaths

and 1 later death. These 2 immediate deaths were preventable and cannot be ascribed to the operation *per se*, but to our inexperience. Follow-up of 12 cases shows that the disease was cured in all but one, and this one presents fistulous openings which drain intermittently due to bone involvement.

5. Pauchet's operation has proved a satisfactory procedure in our hands and is worthy of further trial.

6. Two very low strictures were resected in one stage and they resulted in complete cure.

7. Early diagnosis, in our opinion, followed by an excision operation, is the best treatment for fibrous strictures of the rectum.

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LIGATION OF THE INNOMINATE ARTERY FOR INNOMINATE ANEURYSM USING RUBBER BANDS

Report of a Case

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OF the fewer than 100 operations performed on the innominate artery since Valentine Mott's initial report in 1818, approximately 25 per cent have been for innominate aneurysm. Greenough in 1929 collected from the literature 91 ligations or attempted ligations of the innominate artery; only 17 were performed for aneurysm of this vessel, and in only 13 was the artery actually tied. In 1937 Rundle added 8 cases to Greenough's 13 (3 of these Greenough had listed as subclavian aneurysm)[1] and Brock in 1941 added another. From these reports and including the present case it appears that the innominate artery has been ligated some 23 times for aneurysm.

The relative infrequency of ligation of the innominate artery for aneurysm is understandable because of, (1) the rarity of the condition (innominate aneurysm accounts for less than 3 per cent of the total), and (2) the high mortality of the operation (Table I). A successful case was not reported until 1911 by Sargent although Cuneo according to Guinard successfully ligated the innominate artery for aneurysm in 1905. Many more successful ligations have been performed during the past 25 years but the procedure remains hazardous, with secondary hemorrhage still the chief cause of death (Table II).

Greenough gives a detailed description and analysis of the types of operations employed on the innominate artery including proximal or distal ligation or both, ligation of the innominate and subclavian or carotid vessels, triple ligation of the innominate, subclavian, and carotid arteries, triple ligation and excision of the sac and innominate, carotid and vertebral ligation in which silk, hemp, ox aorta, ox peritoneum, kangaroo tendon, carbolized catgut, chromic catgut, horsehair, silver wire, and many other materials were used as ligatures. He concludes that multiple ligation is advisable, combinations including the subclavian surpass those with the carotid, and the vertebral should not be included.

TABLE I.—MORTALITY IN 28 CASES OF OPERATION ON THE INNOMINATE ARTERY FOR INNOMINATE ANEURYSM

	Ligation	Mortality	Attempted ligation	Mortality
Greenough	13	6	4	4
Rundle	8	3	1	1
Brock	1	1	0	0
Trent	1	0	0	0
Total	23	10(43.5%)	5	5

Total number of cases—28 Mortality—15 (53.5%)

After careful evaluation of the operative treatment of innominate aneurysm Rundle reaches similar conclusions: (1) if an attempt is to be made to ligate the innominate trunk it is essential to split the sternum; otherwise access is inadequate and the ligature may fail to occlude its lumen. (2) Simple proximal ligation as a method of treatment is most unsuitable; while necessitating as thorough an exposure as the more complete operation, it gives the poorest results and is too prone to be followed by cerebral vascular complications.

In any type of ligation of the innominate trunk, there are two circulations to consider,

TABLE II.—CAUSES OF DEATH IN 15 CASES OF OPERATION ON THE INNOMINATE ARTERY FOR INNOMINATE ANEURYSM

Secondary hemorrhage	7 (46.6%)
Cerebral complications	3
Shock	2
Tracheal compression	1
Traction on aorta	1
Uremia	1
Total	15

From the Department of Surgery, Duke University Hospital, Durham, North Carolina.

[1]Early reports of ligation of the innominate artery for aneurysm are frequently difficult to interpret because of the failure of the authors to describe the exact location of the lesion.

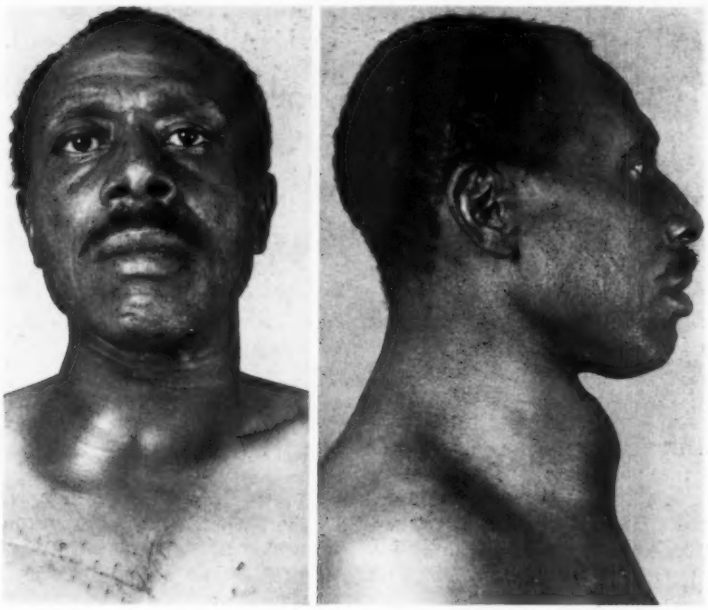

Fig. 1. Anterior and lateral views of the patient 10 days after operation. The operative scar is clearly visible. The aneurysmal mass no longer pulsates but is approximately the same size as on admission.

the peripheral and the cerebral. Greenough in 75 ligations found no cases of gangrene of the homolateral arm although there were "several cases of atrophy." There were 7 deaths from cerebral lesions, some of which must be attributed to ischemia.

Although the recommendations for surgical therapy outlined above are sound they are not always applicable, a fact well illustrated by the following case which presents several unusual features, namely: (1) the approach to the innominate artery was through the chest rather than the sternum since it was feared that manipulation of the sternum or clavicle would result in the tearing of the wall of the aneurysm; (2) rubber bands were used to ligate the vessel; and (3) the aneurysm completely disappeared following proximal ligation of the innominate trunk.

CASE REPORT

R. W., A-51137, 52 year old colored male, was first seen at the Duke Hospital November 11, 1940. At that time he had a strongly positive blood serology and spinal fluid. A diagnosis of central nervous system syphilis was made and the patient referred to the local Department of Public Health where he received a course of antiluetic therapy.

He returned to the clinic May 31, 1944, stating that 1 month prior to his visit a small "knot" the size of a walnut had appeared suddenly at the base of his neck on the right after a severe coughing spell. The cough had continued and the "knot" had grown rapidly in size. He had no obstruction to his breathing but had noticed some hoarseness and dysphagia. He complained also of throbbing headaches which seemed to be synchronous with his heart beat.

Physical examination revealed fixed pupils, a blood pressure of 148/110 in the right arm and 140/100 in the left, a heart slightly enlarged to the left with an irregular rhythm due to dropped beats, and a late diastolic murmur over the aortic area. Just above the clavicle and resting on it was a large pulsating, definitely expansile mass measuring approximately 10 by 12 by 7 centimeters (Fig. 1). The mass extended beyond the midline although it was predominately on the right. The trachea was markedly deviated to the left, and laryngoscopic examination was unsuccessful. The size of the aneurysm prohibited anteflexion of the head.

Roentgenograms of the chest (Fig. 2) showed slight enlargement of the heart to the left with some tortuosity of the aorta but no definite aneurysm of this vessel. A shadow in right supracardiac region

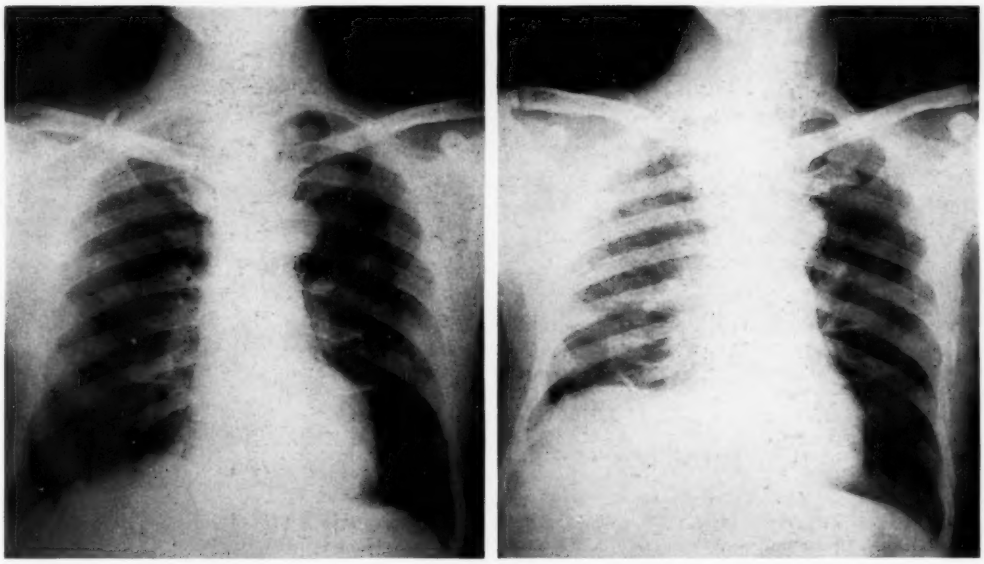

Fig. 2. a, Preoperative roentgenogram of the chest showing the shadow in the right supracardiac area characteristic of an enlarged innominate artery, slight enlargement of the heart to the left and tortuosity of the aorta but no definite aneurysm of this vessel. The trachea may be seen far to the left. b, Seventeenth postoperative day. Roentgenogram of the chest showing the elevated diaphragm on the right.

was characteristic of an enlarged innominate artery. The trachea was displaced considerably to the left.

A diagnosis of aneurysm of the innominate artery and possibly the right common carotid artery was made and the patient referred to the surgical clinic for consideration of ligation of the innominate artery.

He was admitted to the surgical service on June 16, 1944, stating that the mass in his neck had increased in size since his last visit to the clinic. The physical findings were essentially unchanged over those last recorded except for a slight increase in the size of the aneurysm.

The accessory clinical findings were as follows: hemoglobin 13.4 grams (86%); red blood count 4,160,000; white blood count 6,360; blood Wassermann reaction positive, Kahn positive, Kline and Mazzini tests negative. Spinal fluid tests showed: Wassermann reaction, ooooo; colloidal mastic test, oooooo; Pandy, negative; cell count, o.

Fluoroscopy and films of the chest showed the changes described. The electrocardiographic record was indicative of coronary artery disease.

A diagnosis was made of syphilitic aneurysm of the innominate artery, syphilitic cardiovascular disease with cardiac enlargement and myocardial damage from coronary involvement, aortitis, and dilatation of the aorta.

During the 9 days the patient remained in the hospital before operation, the aneurysm increased visibly in size, and rupture appeared imminent. Therefore, in spite of electrocardiographic evidence of coronary involvement and the attendant high operative mortality, ligation was recommended. A week before operation patient was given 2 cubic centimeters of bismuth subsalicylate intramuscularly.

On June 24, 1944, with the patient supine and under pentothal and endotracheal 50 per cent nitrous oxide-oxygen anesthesia, a hockey-stick incision was made over the second rib anteriorly on the right extending vertically along the lateral border of the manubrium to the jugular notch. The underlying pectoral muscles were cut and the second rib exposed and resected as far laterally as possible. The costal cartilage was rongeured away to the sternum; care was taken not to injure the mammary vessels. The pleural cavity was entered through the rib bed. In order to obtain better exposure, the third rib was divided laterally and medially. The under surface of the aneurysm could be visualized readily and palpated at the apex of the pleural cavity. The pleura overlying the great vessels was divided and reflected back. The innominate veins and the superior vena cava were separated from the underlying arch of the aorta and the innominate artery and retracted, exposing the greatly dilated innominate trunk which measured approximately 4 centimeters in diameter at its junction with the aorta. By careful manipulation and dissection, a large goose-neck clamp was passed under the vessel and a cotton tape placed around the artery (Fig. 3). It was feared

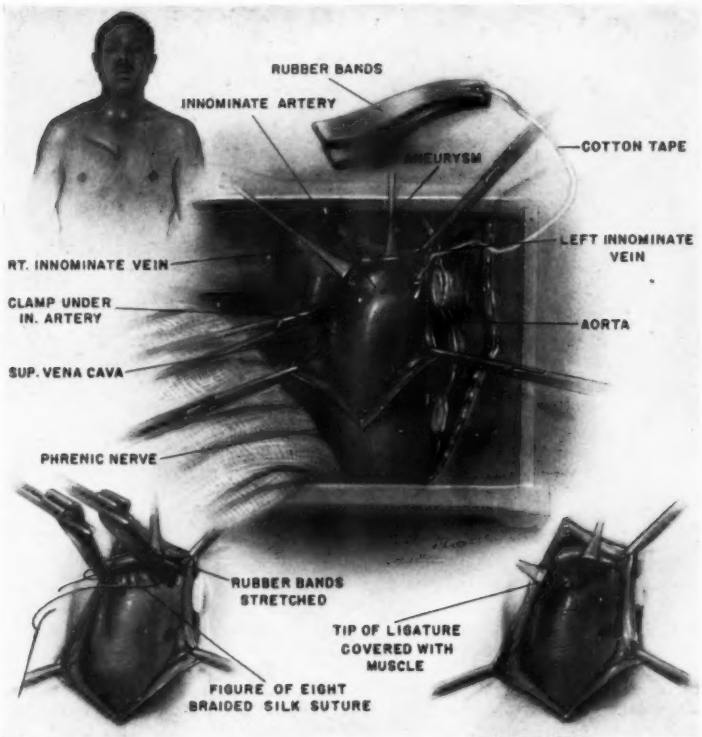

Fig. 3. The right chest was entered through a hockey-stick incision over the second rib (left upper inset). The pleura overlying the great vessels was incised, the fat pushed back, the veins retracted, and the innominate artery exposed. A goose-necked clamp was passed behind the artery and two rubber bands pulled through by means of a tape (central cut). The rubber bands were stretched and sutured anteriorly using heavy braided silk (left lower inset). The ends were trimmed and the protruding nubbin covered with muscle (right lower inset).

that secondary hemorrhage might follow ligation of such a large thin-walled vessel with a narrow nonelastic ligature. Therefore, two new rubber bands 12 millimeters in width and 7.5 centimeters in length were obtained, sutured to the tape, and drawn under the vessel. The bands were then pulled up very snugly around the vessel and sutured together anteriorly using a heavy braided silk figure-of-eight suture. After the lumen of the vessel had been thus occluded, there was immediate cessation of pulsation in the aneurysm and right superficial temporal artery, and the blood pressure and pulse in the right arm could no longer be obtained. After the rubber bands had been trimmed, a small nubbin remained which lay immediately beneath the innominate veins, and the possibility of erosion into these vessels had to be considered. To obviate this, a piece of muscle was sutured over the stiff protruding ends, to form a soft pad between the ligature and vessels. The wound was then closed in anatomical layers, with continuous chromic o Dulox suture for the pleura, interrupted double medium cotton for the muscle and fascia, and interrupted fine cotton for subcutaneous tissue and skin. Patient stood operation well and returned to ward in good condition.

Following the operation no weakness of the homolateral arm or opposite side was noted. He had a fairly stormy course for the first 3 days due to the development of bronchopneumonia, but on the fourth day following penicillin and sulfadiazine therapy his temperature returned to normal. On the fifteenth day small tender, fluctuant areas developed over the crest of the aneurysm. The aneurysm no longer pulsated but had not decreased appreciably in size. Aspiration of the fluctuant areas yielded pus and blood which contained gram positive cocci. To forestall spontaneous rupture, a small incision was made in the skin at the point of aspira-

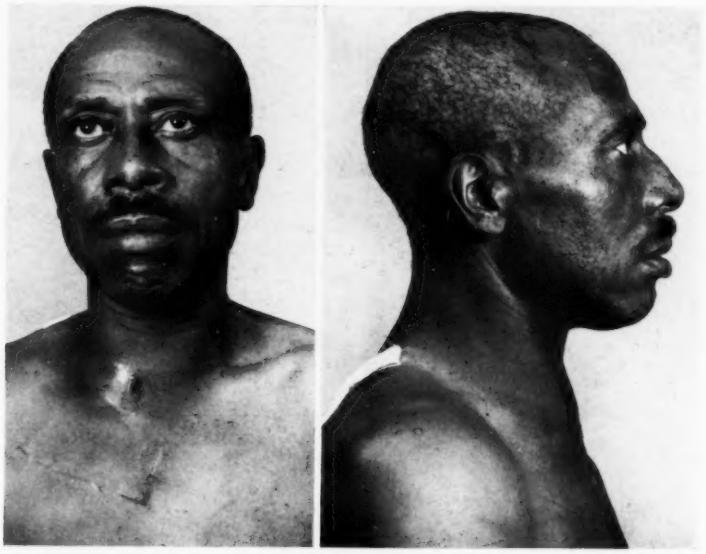

Fig. 4. Three weeks postoperative. Anterior and lateral views of the patient showing almost complete disappearance of the mass. The opening of the small draining sinus can be seen just above and to the right of the jugular notch.

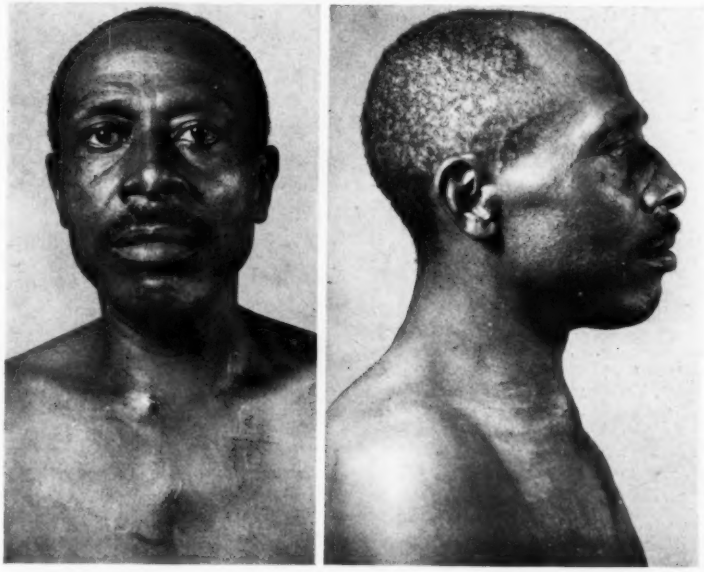

Fig. 5. Six weeks postoperative. Anterior and lateral photographs show a further decrease in the size of the mass. The opening of the supraclavicular sinus tract is evident.

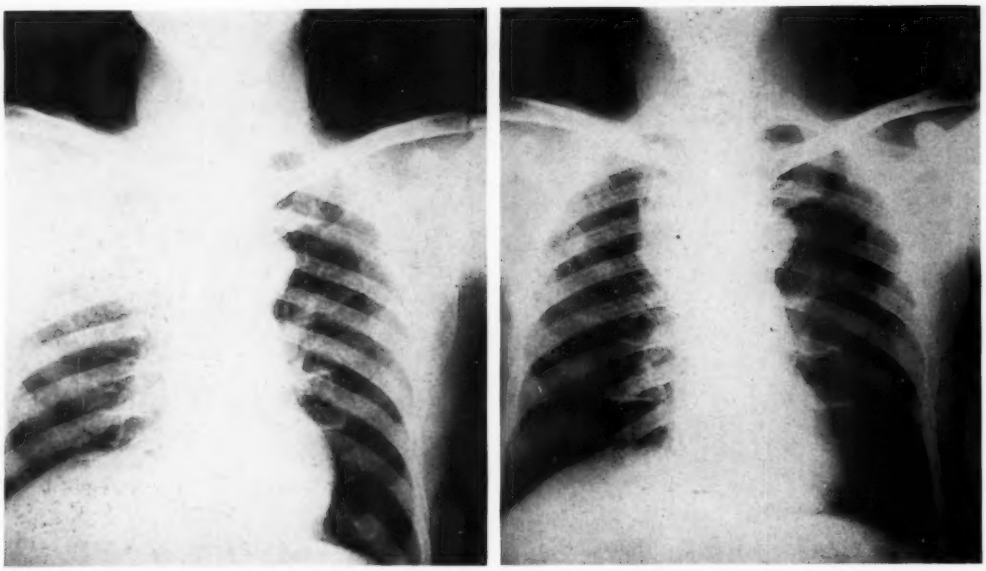

Fig. 6. a, Roentgenogram of the chest made approximately 3½ months postoperatively showing a prominent shadow over the right apex displacing the aortic arch to the left. b, Roentgenogram of the chest made 5½ months after operation showing clearing of the right apex with a residual mass in the region of the innominate artery.

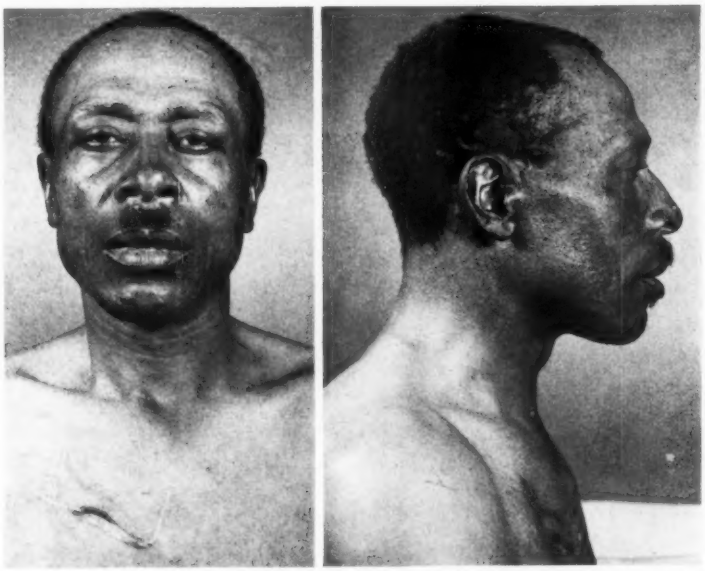

Fig. 7. Ten months postoperative. The mass has completely disappeared and the sinus tracts have healed. The outline of the right sternomastoid muscle is clearly visible. Subjectively the patient is well.

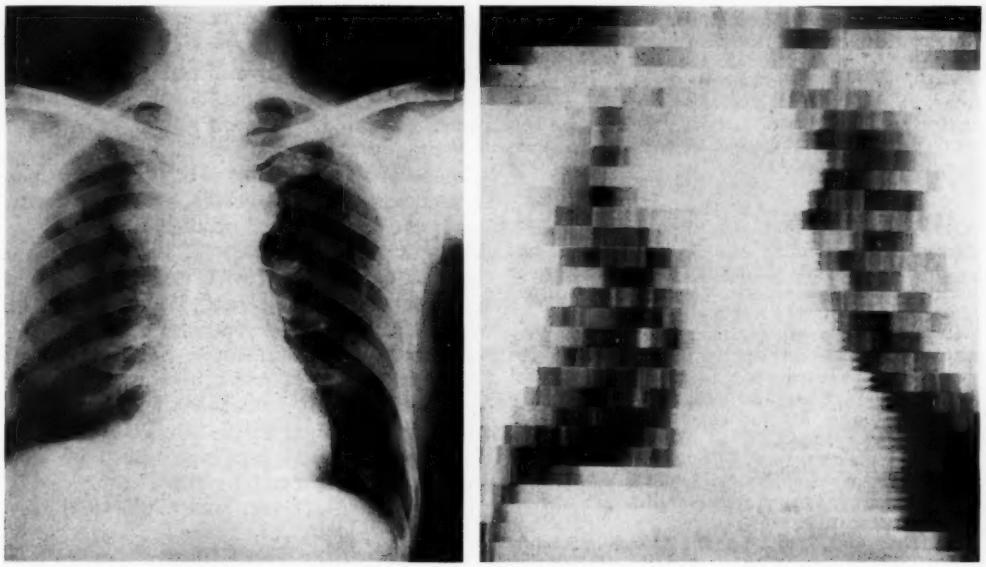

Fig. 8. a, Ten months postoperative. There is a large dense mass in the right supracardiac area at the site of the ligation. The trachea is practically in the midline. The diaphragm has descended. b, A kymogram made of the chest reveals no pulsation of the mass which has been described in a.

tion, and 100 cubic centimeters of pus, old blood, and thrombus were expressed from the neck. No hemorrhage ensued. Following this, the mass in the neck disappeared (Fig. 4). Compresses were applied, the inflammation and induration subsided, and healing occurred except for a small persistent sinus. A chest plate on the seventeenth day showed the chest to be clear, with the trachea still slightly deviated to the left. The right diaphragm was elevated and fixed from stretching of the phrenic nerve at operation (Fig. 2b). A slight pulse was felt in the right arm on the seventeenth day, but the blood pressure could not be recorded. The blood pressure in the left arm was 118/76. Oscillometer studies of the right arm revealed a maximum of 2 units pulsation above the elbow. An electroencephalogram showed no depression of cerebral activity on the right. He was discharged on the twenty-first day with instructions to continue his antiluetic therapy.

On August 7, 1944, the patient was readmitted to the hospital complaining of bleeding from the site at which the infected aneurysm had been drained (Fig. 5). Physical examination and chest findings were essentially as on discharge July 14, 1944.

While in the hospital, fairly brisk bleeding occurred from the sinus with an estimated blood loss of 500 to 700 cubic centimeters. He was given a blood transfusion. A skiodan injection of the sinus tract revealed only a small pocket at the site of the aneurysm. It was felt that the hemorrhage probably had come from the vessels communicating with the old aneurysmal sac. An attempt was made to thrombose these vessels by injecting first a solution of 50 per cent glucose and later 5 per cent sodium morrhuate into the tract. Following this no further hemorrhage occurred. The cavity decreased in size, and the patient was discharged on August 22, 1944.

On August 26, 1944, the patient was readmitted complaining of a swelling under the old thoracotomy wound which later proved to be an abscess. It was feared at first, however, that it might be due to further hemorrhage and since he was afebrile, it was not incised. He was discharged on August 27, 1944.

On September 4, 1944, the patient was readmitted complaining of increase in the size of the swelling under the old incision and further bleeding from the supraclavicular sinus tract. He had some fever and since there was some clouding of the right upper chest on x-ray examination (Fig. 6a), it was decided to explore the mass. On September 7, 1944, the old thoracotomy wound was reopened and a large abscess cavity approximately 8 centimeters in diameter over the apex of the right lung was encountered and drained. The cavity contained a large quantity of thick pus from which nonhemolytic Staphylococcus aureus was cultured. The site at which the ligation had been done could not be visualized, but it was possible that a small sinus at the bottom of the cavity communicated with it. The patient was discharged improved on September 11, 1944.

On September 28, 1944, the patient was readmitted complaining of dyspnea, substernal oppres-

sion, and increasing hoarseness, but no further bleeding. Re-examination of the chest by x-ray revealed that the shadow in the right upper chest was still prominent with displacement of the aortic arch to the left. It was felt that there might be a further accumulation of pus over the apex, and on September 30, 1944, the old wound was again explored. No pus was found. The patient improved and was discharged on November 3, 1944.

On December 13, 1944, the patient was readmitted complaining of sudden onset of severe coughing which had persisted for 12 to 18 hours. He had coughed up 2 cupfuls of blood and had noticed some bleeding from the empyema drainage wound. Bronchoscopic examination was refused.

Physical and x-ray examinations (Fig. 6b) revealed some clearing at the right apex. While in the hospital, he coughed up only a small amount of blood-tinged sputum. The exact source of his bleeding was unknown. He was reassured and discharged on December 15, 1944.

On December 22, 1944, he returned to the clinic, complaining of coughing up blood. His condition was good and his cough had stopped. He was reassured and sent home.

On January 31, 1945, he was again seen in the outpatient clinic with similar complaints. All draining sinuses had healed. He was reassured and discharged.

On February 12, 1945, he returned to the outpatient clinic, stating that he had gotten along well except that he had coughed up a large quantity of blood on 1 occasion. General condition the same.

On April 25, 1945, exactly 10 months after proximal ligation of the innominate artery, the patient returned to the clinic for a check-up. He had been receiving weekly intramuscular injections of bismuth subsalicylate since January 3, 1945. He had no dyspnea, but occasionally coughed up blood-tinged sputum. He had no complaints other than dizziness on lowering his head. He had excellent use of right arm, but stated that in cold weather right hand became cold and stiff; left hand not affected.

On examination the aneurysmal mass had completely disappeared (Fig. 7). The small sinus in this area and the old thoracotomy wound had completely healed. The anterior border of the right sternocleidomastoid muscle was again clearly visible. The superior mediastinum was slightly widened to percussion on the right. The lungs were clear to auscultation. Pulsations in the right brachial and radial arteries were faintly perceptible. Pulsations in the right common carotid and superficial temporal arteries were questionably felt. The blood pressure in the right arm could be heard faintly at 74/60 and 104/74 in the left. Examination of the chest by fluoroscopy and kymography (Fig. 8a, b) revealed a large nonpulsating mass in the supracardiac area at the site of the ligation of the innominate artery. This mass was interpreted as scar tissue and not as an aneurysmal dilatation. The trachea had almost returned to the midline, and the diaphragm had descended and had regained 50 per cent of its motion.

SUMMARY AND CONCLUSION

A case of syphilitic aneurysm of the innominate and common carotid arteries which first appeared after a severe coughing spell has been presented. The aneurysm was ligated proximally at its juncture with the aorta, by the use of two wide rubber bands. Pulsations ceased immediately following ligation although no appreciable decrease in the size of the mass was noted. No weakness of the homolateral arm or opposite side was observed. On the fifteenth postoperative day, the aneurysm became fluctuant and was drained to avoid spontaneous rupture. Approximately 100 cubic centimeters of pus and thrombus were obtained without hemorrhage. Following drainage the mass subsided. Two and one-half months later hemorrhage occurred from a persistent sinus tract at the former site of drainage. An attempt was made to thrombose the feeding vessels by the injection of 50 per cent dextrose and 5 per cent sodium morrhuate solutions. Although these measures appeared to be effective in stopping the hemorrhage, other complications developed. He returned 1 month later with an infection under the old thoracotomy wound which subsided following drainage. Subsequently both the persistent supraclavicular sinus and thoracotomy wound healed with complete disappearance of the aneurysm. There remains a residual nonpulsating mass at the site of ligation, which is believed to be scarring resulting from the irritation of the rubber ligature. Patient has occasional episodes of coughing productive of blood-tinged sputum, due perhaps to some involvement of the trachea in the cicatricial mass. Except for these episodes the patient states that he feels as well as he ever has.

Proximal ligation of a syphilitic aneurysm of the innominate artery with rubber bands has resulted in complete disappearance of the aneurysm and clinical cure of the patient.

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FAILURE OF THE UROGENITAL UNION

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IN a fairly extensive search of the literature, very little reference is found to a failure of union between the vasa efferentia of the testis and the epididymis. Hobday mentions that in the horse the epididymis is occasionally found in the inguinal canal while the testicle is in the abdomen. Kaufman (1922) and Windholz (1926) mention complete separation of the epididymis and testis, and Brunzema (1929) found this condition four times in 104 cases of undescended testis. Wilson (1939) records one case in which the testis was in the inguinal canal and the epididymis was in the scrotum. Ombredanne (1923) describes the separation as occurring occasionally when there is a vestigial testis and Wangensteen (1932) quotes a case of an epididymis with a vestigial structure attached to it which had none of the appearance of a testicle.

UROGENITAL UNION

In a 21 millimeter embryo (7th to 8th week), the wolffian body consists of about 26 tubules, situated in the lumbar region, and all in a process of degeneration. This remnant of the mesonephros is divided into two portions—upper and lower. The upper or epigenital part consists of 5 to 12 tubules, the blind ends of which become surrounded by the epithelial nucleus, forming in the indifferent reproductive gland, so that each comes to be in a sort of bay, in that part of the nucleus from which the rete testis is formed. From the beginning, therefore, the wolffian collecting tubules and the tubules of the testicular rete are in intimate contact, and lie wall to wall. The urogenital union takes place when the two open into each other (Fig. 1) and this appears to occur at very different periods. Felix saw it first in a 60 millimeter embryo-head-foot length.

When union has taken place, the collecting tubules are known as the vasa efferentia. In the 4th to 5th month, they begin to coil at the end nearer the wolffian duct, but remain straight toward the testis. Later, they are surrounded by a firm connective tissue membrane and become the coni vasculosi. All of the 5 to 12 tubules, do not necessarily take part in the union, but if not, they frequently persist as remnants in the epididymis, forming the vasa aberrantia. One or two may unite before joining the rete testis.

The lower or paragenital portion of the wolffian body consists of two or three small tubules, closed at both ends, and persists as the paradidymis.

FAILURE OF UNION

In a series of 42 cases in which patients with incomplete descent of the testis, were operated upon I have seen 3 in which there was no macroscopical union of the testis and epididymis. In 2 of these, the absence of union was confirmed microscopically.

CASE 1. A wireless air-gunner, complained of pain in the right groin since beginning to wear parachute harness. On examination, the right compartment of the scrotum was empty and he stated that the testis had never been down. The right testicle could be felt in the inguinal canal and pressure over it caused the pain of which he complained. The left testicle was well down in the scrotum and it and the epididymis felt normal. No evidence of hernia was noted. October 13, 1941, under nitrous oxide gas, oxygen and ether anesthesia, pentothal induction, the right inguinal canal was opened and the testis was found lying in a patent funicular process, the fundus of which reached to the external ring. When the sac was opened, the testis was seen, lying on the floor, about 1 inch from the internal abdominal ring (Fig. 2). The sac was freed from the floor of the inguinal canal, and the epididymis was found with the globus major almost at the fundus of the processus and completely separated from the body of the testis. The vessels of the spermatic cord were very short and the testis, epididymis, and sac were removed. On microscopic examination the testis showed the usual picture of an undescended organ. The seminiferous tubules were composed of a single layer of cells; occasional spermatogonia were present but no spermatozoa. There was no microscopic connection between the body of the testis and the epididymis, although there appeared to be one or two ducts leading from the upper pole of the testis. The termination of these ducts were not identified.

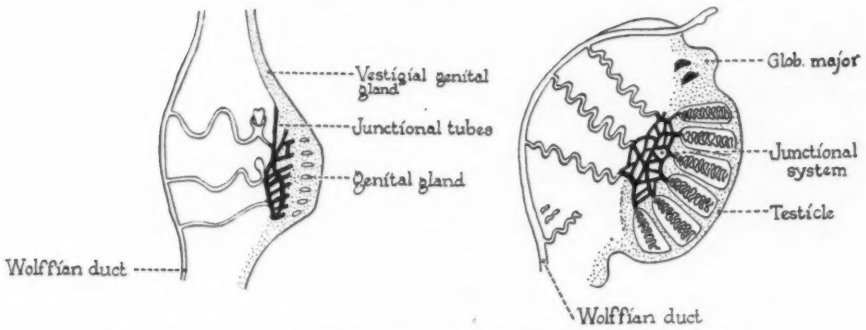

Fig. 1. A diagrammatic representation of the urogenital union. (After Keith.)

CASE 2. Attended complaining of occasional swelling, with pain in the right groin for some 12 months. The right testicle had never been in the scrotum. A small oblique right inguinal hernia reaching to the external ring was found; the right testicle was not felt. The left testicle was well down in the scrotum and it and the epididymis appeared normal. On May 2, 1942, under nitrous oxide gas, oxygen and ether anesthesia, pentothal induction, the right inguinal canal was opened. A small patent processus vaginalis was found. The testis was intra-abdominal, but the base of the mesorchium was just inside the inguinal canal (Fig. 3), and the testis could be brought into the canal. His attacks of pain may have been due to intermittent prolapse of the testis and strangulation of the cord. The vas ran down the canal on the posterior wall of the sac and terminated in a splayed-out epididymis which had no connection with the body of the testis. The vas and epididymis could be brought well down, to reach the bottom of the scrotum, without difficulty, but the testis could not on account of the shortness of the vessels of the spermatic cord. The testis, epididymis and sac were removed. Microscopically, the picture was similar to that in Case 1.

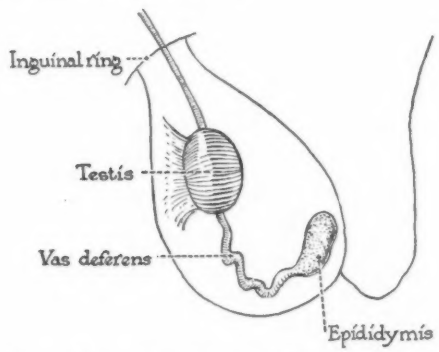

Fig. 2. Failure of descent of the right testis and failure of union with the epididymis.

CASE 3. Attended with a large left sided scrotal hernia which had gradually been increasing over a period of 10 years. The hernia was easily reducible but no testicle was felt after reduction. There was a suggestion of a thickened structure, in the posterior wall of the sac, in the empty scrotum, and a pre-operative diagnosis of atrophy of the testis was made. On December 7, 1942, under nitrous oxide gas, oxygen and ether anesthesia, pentothal induction, the left inguinal canal was opened. A large patent funicular process was found. When the sac was opened, the testis was seen lying on the floor (Fig. 4), half an inch from the inguinal ring, and bound to the sac by adhesions. The vas passed down to the scrotum and terminated in a splayed-out epididymis. This had no macroscopic connection with the testis. The funicular process was divided proximal to the latter and cleared from the cord and epididymis. The testis was then easily mobilized and brought into the right scrotal compartment. The floor of the canal was repaired with a strip of fascia

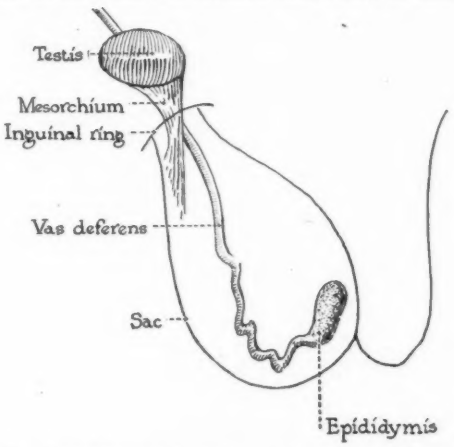

Fig. 3. An intra-abdominal right testis and failure of union with the epididymis.

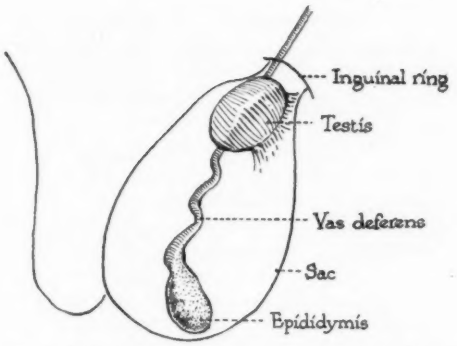

Fig. 4. Failure of descent of the left testis and failure of union with the epididymis which is well down in the scrotum.

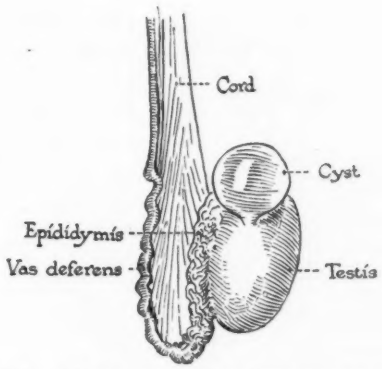

Fig. 5. A single cyst in the mediastinum testis.

taken from the aponeurosis of the external oblique.

These 3 cases would undoubtedly appear to illustrate failure of the urogenital union. During the past 3 years I have almost invariably included an examination of the testis on each male patient who has been referred to me. I have not observed anything which would suggest complete failure of union in a normally descended testis and it is probable that this occurs only in association with incomplete descent. However, I have been struck by the comparative frequency of the occurrence, in young adults, of a small cyst in the region of the mediastinum testis, and believe that not infrequently, this is due to a partial failure of the urogenital union.

Ogier Ward (1922) reported 17 cases of spermatocele and described the etiology. The youngest of these patients was 41 years and the average age was 55 years. He considers it as a disease of maturity and that a spermatocele is a retention cyst of unknown pathology. Dorne (1926) reviews the literature on the subject and also considers that the condition is a retention cyst. Among the etiological factors, he mentions trauma, gonorrhea, or any previous inflammatory process. Rolnick (1928) in the routine examination of 55,000 men for spermatocele, found a clinical incidence of 1 per cent. He operated on 12 patients and found that it was possible to dissect out the cyst in only one case, which was shown to have been formed from a distended tubule. He attempted to produce true spermatocele in 28 dogs and failed in each case. McCrea (1935) gives the following classification of cysts in relation to the epididymis: (a) cystic disease of the epididymis, (b) cysts developing between the testis and the head of the epididymis, (c) cysts of vestigial structures near to or attached to the epididymis. His view is that (a) and (b) arise from obstruction but that obstruction does not necessarily result in cyst formation. He quotes Kocher, and Monod and Terrillon as having described dilatation of the ductuli efferentes and considers this to be the cause of, or a later step in, the dilatation of the epididymis. He considers multiple cysts to be more common, and more common in the epididymis than anywhere else. He also considers that (a) and (b) are retention cysts resulting from obstruction.

In the past 3 years I have seen some 12 cases of single cyst formation in the region of the mediastinum testis occurring in men under the age of 25 years. A colleague, aged 43, has had one since puberty. The large majority of patients were quite unaware of any abnormality and in most cases no comment was made on it. (It is rather extraordinary how many cases of large scrotal hernia of which the patient is quite unaware are discovered at routine medical examination.) These cysts vary in size from that of a pea to a hazel nut. They give rise to no symptoms or disability and therefore the opportunity for surgical intervention—certainly in the Service—is rare. In those that have been aspirated the fluid has contained scanty spermatozoa.

I believe that these cysts form where there has been a partial failure of the urogenital union, just after the commencement of spermatogenesis.

CASE 4. Presented himself with a left inguinal hernia. On examination a cystic swelling the size of a small nut was found in the region of the mediastinum of the right testis. Aged 24, he was unaware of this and therefore had no idea as to how long it had been present. At operation, after the hernia had been repaired, an incision was made in the right scrotum and the cyst was found lying against the epididymis, deep to the tunica vaginalis (Fig. 5). It was rather pear-shaped with the narrow or tail-end toward the testis. In the cyst fluid were scanty, faintly motile spermatozoa. The cyst appeared to be a distended vas efferens.

I have noticed that occasionally, after epididymectomy, a cystic swelling forms in the region of the mediastinum testis. It makes its appearance within a few weeks of the operation and may grow to the size of a hazel nut. In 2 such cases in the last 18 months scanty spermatozoa were found in aspirated fluid. After aspiration the cyst refilled within a few days. It has all the characteristics of a spermatocele and has occurred when there is a complete absence of union between the testis and the collecting system.

SUMMARY AND CONCLUSION

Failure of the urogenital union has received only scanty attention in medical literature and very few cases have been described. Three cases of complete failure of union occurring in a series of 42 adults operated upon with incomplete descent of the testis are now reported. It is thought that complete failure of union occurs only in association with undescended testis. Incomplete failure of union is put forward as a suggested cause for the occurrence of single mediastinal cysts in young adults.

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PRELIMINARY REPORT OF A METHOD FOR THE PREVENTION OF LEAKAGE OF INTESTINAL ANASTOMOSES

An Experimental Study

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THE methods herein described were evolved for colon anastomoses but are applicable to all other gastrointestinal anastomoses, including small bowel anastomoses, gastroenterostomies, and closure of the duodenal stump.

It was noticed both in the postmortem department and in instances in which experimental sutures had been put into redundant exteriorized colon (when it was brought out of the abdominal wall after the operation of excision of the rectum), that each particular suture hole became infected and therefore a potential source of sepsis or leakage. Thus sutured anastomosis of the colon must always have an element of risk, and although, with the bringing of peritoneum to peritoneum with silk sutures which traverse only peritoneum (where this is present), the risk is minimized, its dangers in any but the most experienced hands has led, in many cases, to the adoption of Paul-Mikulicz procedures followed by nonsuture anastomosis with a crushing clamp, "aseptic anastomosis" techniques, and many other methods. It has been long recognized that the most important sutures are those that bring peritoneum to peritoneum, and in some methods of "aseptic" anastomosis no attempt is made at mucosal apposition by suture. Another method of nonsuture anastomosis is the Murphy button. This method gave safe anastomoses of the small bowel with peritoneum to peritoneum junction without sutures (where the bowel is covered by peritoneum), although the button is seldom used these days. Anastomoses in parts of the bowel not completely invested by peritoneum are most difficult to accomplish successfully by any method.

The problem of suturing the large intestine can be considered to be comparable to suturing the inner tube of a motor tire. Here sutures cannot be employed to repair rents because each stitch put into the rubber tube would leak air; therefore punctures in tires are mended by "vulcanizing on" patches over the holes.

The method herein described involves the "vulcanizing on" of peritoneal grafts or split-skin grafts over the suture line, whether or not the surface is covered by peritoneum. It is a procedure supplemental to the usual methods of anastomosis. It takes very little more time and there is nothing to lose if it fails.

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METHOD EMPLOYED

In 1943, Sano reported a method of "sticking on" skin grafts using dried plasma and leucocyte cream; the graft was placed in contact with the recipient area without sutures. Adhesion occurred in a few minutes. In 48 hours the graft had a blood supply and was completely fixed in 4 days. Young and Favata in 1944 further simplified this procedure, using thrombin solution on the unwashed skin graft, and normal pooled plasma on the recipient area. This method has been used successfully by the author in applying skin grafts cut with the dermatome, thus avoiding the necessity of suturing the graft in position and of applying pressure. Further work by Cannady (1943) had shown that strips of skin were useful in repairing a hernia and that no harm came from dermis in the tissues.

An experimental study was therefore undertaken to see whether skin or peritoneum could be grafted over the suture line of colon anastomoses, on the assumption that any method which would be successful in the colon would be at least equally successful in the small bowel and stomach. The method of fibrin fixation of a graft to bowel would be physiologically sound as, after all, the "normal" formation of intra-abdominal adhesions must occur by that method. Fibrin fixation of skin grafts was an established fact and had been personally found useful. However, it remained to be seen whether peritoneum would "receive" peritoneal grafts; whether intracolonic pressure would "blow off" grafts; whether soiling and consequent sepsis would prevent the graft from "taking"; and whether such a convenient strong grafting material as skin or "split skin" could be used in the peritoneal cavity.

EXPERIMENTAL PROCEDURES

Dogs were used in the experiments because they have a strongly mobile small colon which

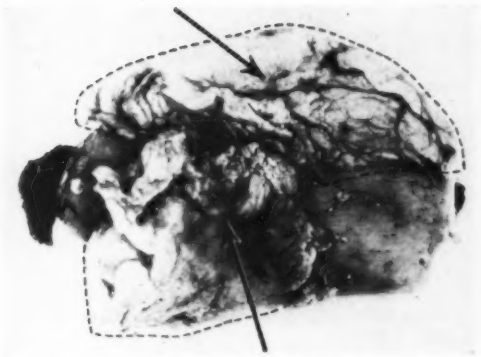

Fig. 1. Experiment 1. Showing most of free omental graft still sticking to the suture line.

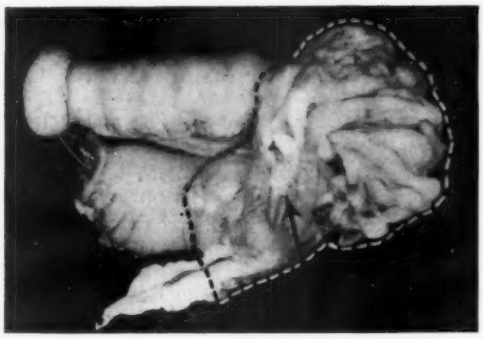

Fig. 2. Experiment 2. Showing omentum stuck over peritoneal graft which was also firmly stuck in position.

makes surgical procedures difficult and are susceptible to general peritonitis; therefore, it followed, that they were suitable for testing the efficacy of the graft. Ten small dogs were used; in the first 6 differing trial techniques were used, and in the succeeding 4 at a later date a more or less standardized technique was followed. In all cases the ascending colon was cut across between rubber bowel clamps to stop undue fecal contamination, and then the ends were joined together by a single continuous through-and-through silk suture which went through all bowel wall layers at once and encircled the bowel and was tied only when it came back to the place from which it started. This admittedly inadequate method of anastomosis was not assisted by the use of either a Miller-Abbott tube or an artificial anus to take tension off the suture line. In some cases feces could be observed to issue from the ineffective suture line immediately after the removal of the clamps, and in the control experiment in which this suture was used alone, death occurred within 24 hours, and it was found that the abdominal cavity was full of feces. It will thus be seen that the greatest possible strain was thrown on the grafts in testing their efficacy in the prevention of leakage of intestinal contents.

TABLE I.— PROTOCOL

Group A. No pressure of any kind applied.

Experiment	Type of graft	Result	State of graft	Soiling of peritoneum
1	Free omental	Death 24 hrs.	Half graft adherent	+++
3	No graft on suture line (peritoneal graft stuck well on gut)	Death 24 hrs.	.....	++++
4	Peritoneum	Death 12 hrs.	Adherent except at mesenteric border	++
5	Whole thickness skin	Death 30 hrs.	Well adherent except at mesenteric border	+

Group B. Free peritoneal grafts held in position for about 5 minutes with pressure.

2	Peritoneum	Alive (killed 60th day)	Adherent	Nil
7	Peritoneum	Alive (killed 60th day)	Adherent	Nil
8	Peritoneum with a hole in it	Death 72 hrs.	Graft fully adherent leak had occurred through the hole	++
9	Peritoneum	Death 48 hrs.	Adherent	Nil
10	Peritoneum	Alive (killed 60th day)	Adherent	Nil

Group C. Exteriorized colon.

	Whole thickness skin and peritoneum		Both adhered and remained adherent	

RESULTS

In the first 6 experiments various procedures were used, but in only 1 case (Table I) was the graft applied with pressure. This dog lived and was killed at the end of a week, when the graft was found sticking firmly in position without any sign of leakage or peritonitis. (In the dog in which no graft of any sort was used, death occurred within 24 hours with feces being widespread throughout the peritoneal cavity.) In the remainder in which whole thickness skin, peritoneum, and omental grafts were used, all were found to be firmly stuck on to the anastomosis despite the fact that pressure during application had

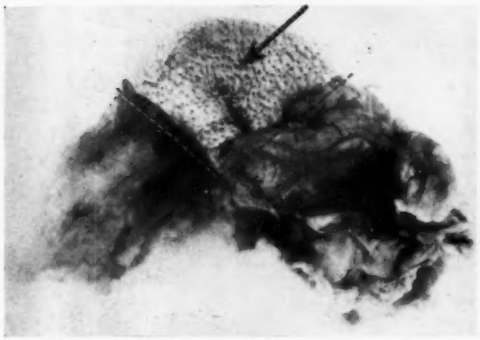

Fig. 3. Experiment 5. Showing skin adherent to suture line.

not been used, but in these cases (with "no pressure" technique) leakage had occurred at one spot or another, usually at the mesenteric border.

In the second series of 4 cases, peritoneal grafts only were applied with pressure for about 5 minutes. No sutures of any sort were used to fix or to hold the grafts in position; in these 4 cases, 2 were alive and perfectly well at the end of 6 days, and when they were killed no peritonitis was found. In each of these cases the graft was strongly fixed in position. In one other case death occurred in 48 hours from a general hemorrhage throughout the peritoneal cavity, no peritonitis being present and no bowel leakage having occurred, and the graft was still firmly fixed in position. The fourth died after 72 hours with general peritonitis. The graft in this dog was accidentally perforated in cutting, but it was applied with the hole over the suture line, just to see what would happen. This graft was stuck firmly in position and could not be pulled off the bowel, but feces leaked through the hole in the graft (Fig. 5).

Thus all 5 peritoneal grafts which had been applied with pressure stuck firmly in position, and of these 2 dogs died, 1 from hemorrhage and 1 from leakage through a hole in the peritoneal graft made while it was being taken (Fig. 5). Of the 9 cases in which grafts were applied, all grafts were found adherent at least in part. In the experiment in which no graft had been applied to the suture line, a peritoneal graft applied to the colon elsewhere was firmly adherent.

The application of these findings to the human was first done on exteriorized redundant bowel left outside the abdominal cavity after the operation for excision of the rectum. A graft of whole thickness skin and a graft of peritoneum were both taken at the time of operation, and refrigerated for 6 hours before application to the exteriorized

Fig. 4. Experiment 7. Showing peritoneal graft stuck firmly in position.

colon on its peritoneal aspect, plasma being applied to the bowel and a few drops of thrombin solution to the graft. Pressure was applied for 4 minutes and the graft adhered readily. They were firmly fixed in 24 hours, and by the third day appeared to have a blood supply, and by the fourth day the edges could not be lifted. The fixation was easier than with dog plasma because human plasma is much more sticky than dog plasma, and of course human bowel and skin and peritoneum are much larger and easier to handle than are the filmy dog peritoneum and small dog colon, which had presented many technical difficulties in the spreading of the graft.

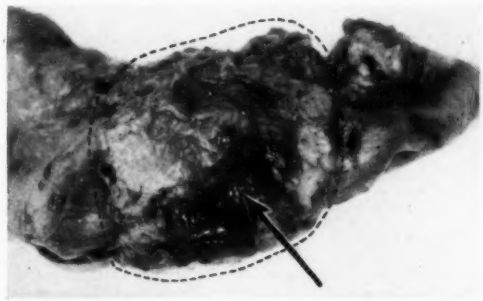

Fig. 5. Experiment 8. Showing edematous peritoneal graft stuck firmly in position with arrow pointing to hole in the graft through which soiling of the peritoneal cavity had occurred.

Fig. 6. Experiment 10. Showing mass of omentum adhering to peritoneal graft which was firmly fixed in position.

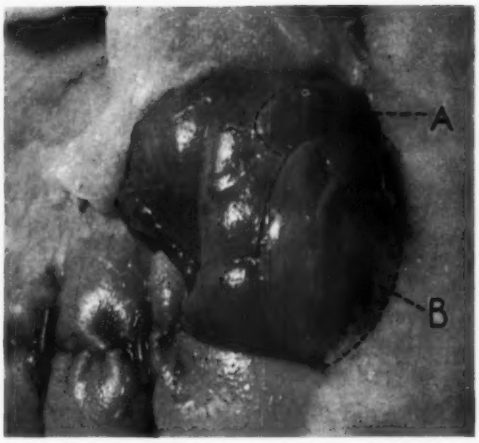

Fig. 7. Human. Peritoneal and skin grafts applied to exteriorized human bowel. *A* points to the skin and *B* to the peritoneum. (Photograph taken on fourth day.)

Observation of the grafts in the dogs and man shows that they adhere with a reasonable tenacity immediately, that by 48 hours they are quite firmly adherent, and that at the end of a week they could not be pulled off. After 48 hours the grafts appeared to be edematous and to stay so for some days.

It is reasonable to suggest, therefore, that the employment of these grafts in intestinal anastomoses in man will be of great value and may obviate the use of "staged" operations now commonly performed in order to avoid the risk of leakage from the suture line.

PROTOCOL OF EXPERIMENTS

In all cases a right upper paramedian abdominal incision was made and the ascending colon cut across about 4 inches from the cecum. The ends were then joined together with a continuous silk suture starting on the mesenteric border and traversing all coats and being tied again on return to the mesenteric border. Chloroform anesthesia was used throughout. The first 6 experiments were done on August 26, 1945, and the second 4 on September 7, 1945. Small dogs were used.

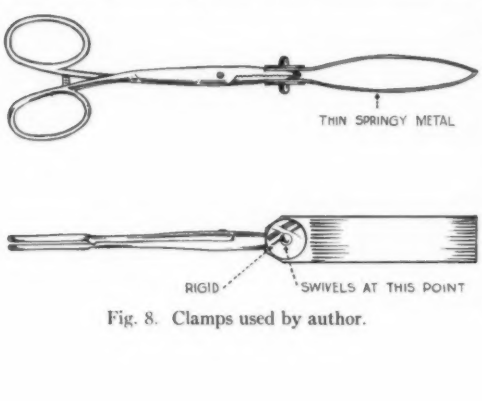

Fig. 8. Clamps used by author.

Group A.

Experiment 1. A free graft cut from the greater omentum was swabbed with a large amount of thrombin solution, made by dissolving 5000 units in 5 cubic centimeters of saline. The suture line was flushed with dog plasma (oxylated) taken from a single dog 5 days before. The graft was laid over the bowel and a few sutures of silk fixed it on to the bowel. *Death* occurred in about 24 hours with a generalized peritonitis, and only half of the graft was found to be still adherent to the suture line.

Experiment 2. A strip from the anterior peritoneum about half an inch wide was wrapped round the bowel and moistened with a little thrombin solution and the suture line was swabbed with plasma. The strip was held in position over the suture line by a firm metal clamp which compressed the bowel so that it became flat. The clamp was removed after 5 minutes, and the graft was found to be well stuck to the flat bowel. *Time of death*—this dog was alive and well and was killed by chloroform on the sixth day when no peritonitis was found, and the graft could not be pulled off. Omentum had also stuck to one side of the neighborhood of the anastomosis.

Experiment 3. No graft or thrombin was used. A postage-stamp size of peritoneum was cut and applied to the cecum after having been swabbed with thrombin and the cecum with plasma. It stuck on well and was found to be still stuck on after death. *Time of death*—at 24 hours. At postmortem the peritoneal cavity was found to be full of feces.

Experiment 4. A strip of anterior peritoneum about half an inch wide was bandaged around the anastomosis. The graft was first dried and then just moistened with thrombin. Plenty of plasma was put on the bowel itself, but no

pressure was applied. *Time of death*—at about 12 hours. A generalized peritonitic reaction and soiling of the peritoneal cavity were present, and there was a leakage from the mesenteric border where the graft was not stuck on. For the remaining circumference of the bowel the graft was firmly stuck on.

Experiment 5. A strip of whole thickness skin about half an inch wide was moistened with a few drops of thrombin and applied like a bandage round the bowel. The ends did not meet very nicely round the mesenteric border. No pressure was applied. A patch of submucosa was moistened with thrombin and applied to the bowel on which plasma had been put about an inch from the line of the anastomosis. *Time of death*—at about 36 hours. At postmortem there was a slight peritonitis present. The graft had stuck on well, but there was a leak at the mesenteric border. The submucosal graft was well adherent to the bowel.

Experiment 6. A free omental graft about 2 inches by an inch was dried and a small amount of thrombin solution applied, and then it was wrapped around the bowel on the site of the anastomosis—no pressure being applied. *Time of death*—at about 24 hours. Some of the graft had not adhered. No definite leakage could be found.

Group B

Experiment 7. A graft of peritoneum plus muscle about three-quarters of an inch wide and an inch and a half long was swabbed with 3 or 4 drops of thrombin solution on its peritoneal side, which was then applied to the line of anastomosis which had been swabbed with plasma. The graft was pressed into position by two clamps for 5 minutes. It stuck well on to the flattened bowel. *Time of death*—this animal was frisky and well on the sixth day, when it was killed. *Postmortem report*—a wound abscess was present, but there was no peritonitis and the graft had stuck on well and surrounding small bowel had also adhered to one side of the graft.

Experiment 8. A strip of peritoneum half an inch wide and 2 inches long which had a hole in the middle of it (made on taking it from the abdominal wall) was applied to the bowel on which plasma had been swabbed after having been moistened with 3 or 4 drops of thrombin solution. It was held in position with two clamps and on removing the clamps after 5 minutes the graft had stuck on well to the flattened bowel. *Time of death*—about 72 hours. *Postmortem report*—there was a general peritonitis present. The graft had still stuck firmly in position and could not be pulled off, but through the hole in the center of the graft feces had contaminated the peritoneal cavity.

Experiment 9. A strip of peritoneum half an inch wide and 2 inches long was moistened with thrombin and held over the suture line with a pressure clamp for 5 minutes. *Time of death*—48 hours. *Postmortem report*—a very extensive hemorrhage into the peritoneal cavity, but with no soiling or peritonitis, and the graft was still firmly in position with no leakage apparent.

Experiment 10. A three-quarter inch by 2 inch strip of anterior peritoneum was wrapped around the bowel two and a half times after having been moistened with thrombin and the bowel having been swabbed with plasma. It was clamped on for 5 minutes with a pressure clamp, and stuck on well. Then thrombin solution was swabbed on to some of the greater omentum and plasma was put over the bowel in the neighborhood of the graft and on the graft. Then the omentum was wrapped loosely round the anastomosis area. *Time of death*—dog was very well and frisky and was killed on the sixth day. *Postmortem report*—no peritonitis was present and the omentum was wrapped irremovably around the grafted bowel, and the graft was also firmly fixed in position.

The possible human applications of these findings on dogs and the human bowel are that with the usual methods of anastomosis as used in either gastroenterostomy, operations on the esophagus, gastrectomy, closure of the duodenal stump, and small or large bowel anastomoses, the suture line can be very rapidly reinforced by a strip of anterior peritoneum sufficient to go round the bowel and with a little to spare, and about three-quarters to an inch in width. This would be moistened with a few drops of a solution of 5000 units of thrombin in 5 cubic centimeters of saline, and applied to the suture line which has been swabbed with pooled human plasma, most conveniently obtained from a blood bank. Both these solutions keep a long while in the refrigerator, and indefinitely in the desiccated form. This procedure could be done whether or not there is peritoneum on the suture line. Pressure would then be applied for 5 minutes by medium of some such type of clamp as used by the author (Fig. 8), and then the intestines would be carefully returned to the abdominal cavity; if handled roughly in its early stages, the graft may be rubbed off before becoming firm. As a further precaution and where anatomically possible, omentum could be moistened with thrombin and applied to graft and bowel which has been painted with plasma. This will then adhere and form "artificial" adhesions, as was shown in experiments 10 and 2. Thus, a rapid and easy means of omental reinforcement of suture lines is available. Further, for some time it has been the practice of the author, before suturing, to moisten with thrombin solution, one side of intestines being anastomosed and the other side with plasma solution. Thus, the normal sealing and repair of bowel are speeded up during the few important hours when the bowel is quiescent following laparotomy.

SUMMARY AND CONCLUSIONS

The theoretical basis of a quick, easy method of increasing the safety and scope of a gastrointestinal tract anastomosis is described. Experimental results in dogs and application in a human being are brought forward in support of this method.

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UTILIZATION OF HENLE'S LIGAMENT, ILIOPUBIC TRACT, APONEUROSIS TRANSVERSUS ABDOMINIS AND COOPER'S LIGAMENT IN INGUINAL HERNIORRHAPHY

A Report of 162 Consecutive Cases

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IN November of 1943, because of the urgent need for replacements in the Army, it was decided to induct those men who previously had been deferred because of inguinal hernias. The Station Hospital, Fort Douglas, Utah, was called upon to rehabilitate many of these men as it is adjacent to a reception center, and it seemed advisable to keep them near home until they could undertake basic training.

To plan an operative technique that would make recurrence under the strain of training and combat less likely, we decided to review available hospital operative records on recurrent hernias to determine the point at which they had broken through the abdominal wall. It was found that 75 per cent had recurred as direct hernias superior to the pubic tubercle, and posterior to the external abdominal inguinal ring (Fig. 3). The remainder had occurred as indirect hernias, probably from incomplete obliteration of the sac.

Many of the standard methods of repair of inguinal hernias have employed the principle of suturing the conjoined tendon to the inguinal ligament to reinforce the posterior wall of the inguinal canal. Surprisingly little attention has been paid to the utilization of other tough tissues that exist in this area; namely, the strengthening fibers in the transversalis fascia.

McVay and Anson have recently called attention to the anatomy of the inguinal region and have reanalyzed the structures in that area. They have found considerable variation between their careful dissections and the descriptions ordinarily occurring in standard textbooks, particularly with reference to the transversalis fascia and the conjoined tendon.

TRANSVERSALIS FASCIA

Most texts inadequately describe the transversalis fascia as a structure lining the inner surface of the abdominal musculature (Fig. 3). In our dissections of the inguinal area we found that the transversalis fascia consists of three prominent fibrous structures with intervening connective tissue. These three fibrous reinforcements of the transversalis fascia are: the iliopubic tract, Henle's ligament, and the aponeurosis of the transversus abdominis. For a more detailed description of the anatomy, the work of McVay and Anson should be consulted.

Iliopubic tract. The transversalis fascia is directly continued into the thigh as a part of the femoral sheath. When this fascia is dissected from the inguinal ligament, care being taken not to open the fascia, there is a band of fibers paralleling the inguinal ligament and demarcating the abdominal component of the fascia from that of the thigh. It can be palpated as a tough, fibrous structure posterior to and separate from the inguinal ligament, and cannot be seen unless it is separated from that ligament (Fig. 4). The tract is best seen, anatomically, by severing and retracting the inguinal ligament (Fig. 5). It is of considerable strength, passes inferior to the internal abdominal inguinal ring, and may be traced from the iliopsoas (psoas) fascia in the area of the anterior inferior iliac spine to the pubic tubercle (Figs. 1, 2). Medially, blending with Henle's ligament, the aponeurosis of the transversus abdominis and other less prominent portions of the transversalis fascia, the fibers of this tract insert into the pubic tubercle and Cooper's ligament (Figs. 5, 6). This band of fibers of the transversalis fascia, the iliopubic tract, has always been present and was easily identified. It is a separate structure from the inguinal ligament.

Henle's ligament. Without entering into any historical controversy concerning Henle's ligament (McVay *et al.*) we found in all of our dissections a definite fibrous structure, which seemed to be derived in part from the lowermost portion of the lateral border of the rectus sheath, and in

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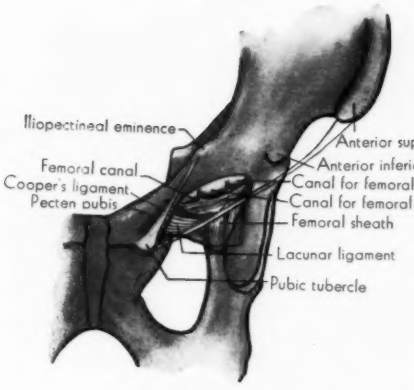
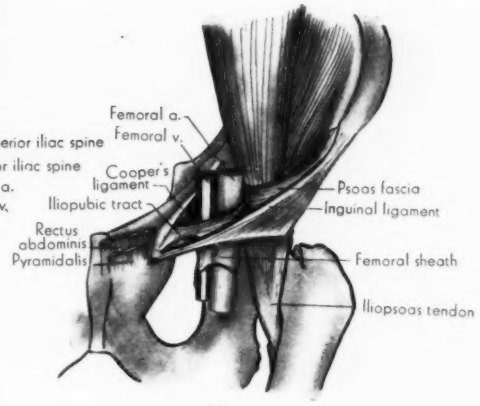


Fig. 1.



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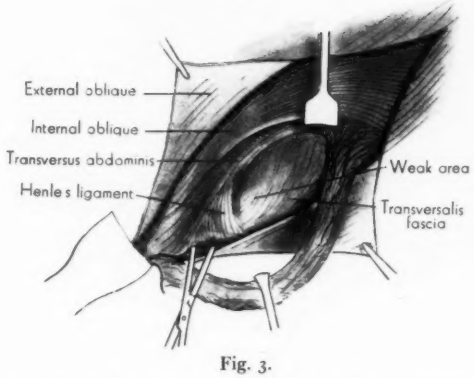

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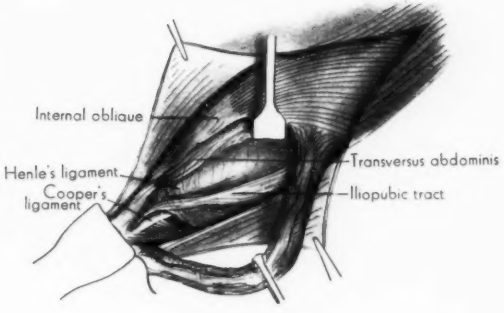


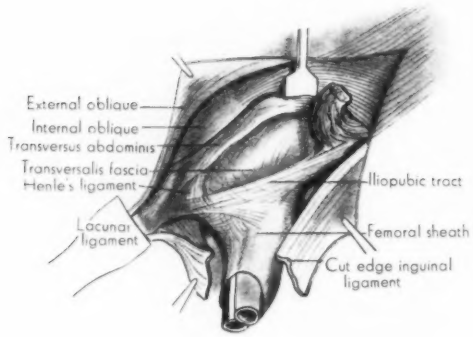
Fig. 4.

part from the lowermost extent of the aponeurosis of the transversus abdominis (Fig. 3). Fanning out inferolaterally, it intermingled intimately with the fibers of the iliopubic tract (Fig. 5). This is the structure originally described by Henle.

Aponeurosis of the transversus abdominis. The lowermost fibers of insertion of the transversus abdominis muscle are aponeurotic and appear as a flat band paralleling the lateral border of the rectus sheath (Figs. 3, 5). Superiorly, some of the fibers pass anterior to the rectus abdominis muscle and form part of the anterior wall of the rectus sheath, while inferiorly, some pass down to blend with Henle's ligament. The major portion of these fibers, however, insert into the pecten of the pubis (Fig. 6).

CONJOINED TENDON

In our experience both in the dissecting room and the operating room, wide variations in the structure and appearance of the conjoined tendon have been noted. The normal anatomy of the conjoined tendon, as described in textbooks, was frequently observed, although often it was difficult to differentiate the conjoined tendon from the lateral border of the rectus sheath. Classically, the conjoined tendon is described as a common tendon of those fibers of the internal oblique and transversus abdominis muscles which form an arch over the spermatic cord (round ligament in the female) and insert into the pubic tubercle and the pecten of the pubis. More careful analysis of our dissections show that this so-called tendon is composed of two sheets of tissue representing those portions of the aponeurosis of insertion of the internal oblique and transversus abdominis muscles lying anterior and in small part lateral, to the rectus abdominis muscle insertion. These two aponeuroses are not a fused tendon as usually described, but two distinctly separable aponeuroses.



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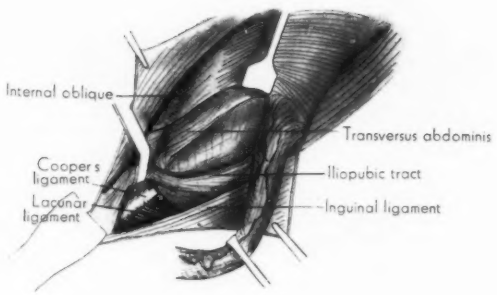

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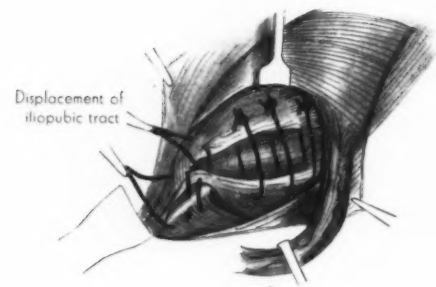

Fig. 7.

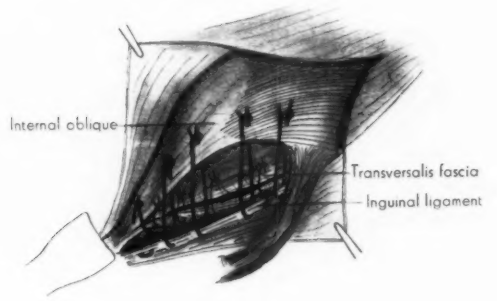

Fig. 8.

Some of our past difficulties in explaining the conjoined tendon to ourselves and to the discerning student lay in the fact that the aponeurotic insertion of the internal oblique failed to reach the pubic tubercle or the pecten of the pubis, but inserted into the anterior rectus sheath, interdigitating with fibers of its fellow several centimeters above the usual point of insertion. Moreover, in some dissections it was found that the aponeurotic insertion of the transversus abdominis was into the lateral wall of the rectus sheath, as described by Robins. These abnormal insertions of the internal oblique and transversus abdominis muscles leave a weakened area superior to the pubic tubercle and posterior to the external abdominal inguinal ring (Fig. 3), the site of most recurrent hernias (Babcock, and Robins). The only structure present in many of these dissections, reinforcing this area, was a weakened transversalis fascia.

COOPER'S LIGAMENT

In addition to the structures described, another important ligament exists, which extends from the pubic tubercle along the pecten of the pubis and continues posteriorly along the iliopectineal line at an angle of approximately 30 degrees to the inguinal ligament (Figs. 1, 2). It disappears near the iliopectineal eminence by blending with the periosteum of the bone, and is intimately adherent to the bone in its entire extent. Because of its strength and position it would seem only logical that it must have considerable importance. To it are attached, from below upward, the pectineal fascia, the lacunar ligament, the aponeurotic thickening of the transversus abdominis, Henle's ligament, and the remaining less distinct portions of the transversalis fascia (Figs. 5, 6).

Harkins and Swenson have reviewed the literature and pointed out that the suturing of the transversalis fascia and attached structures to Cooper's ligament was not new. Such men as Narath (1898), Lotheissen (1898), Fischer (1919), Groves (1923), Stetten (1923), Andrews (1924), Keynes (1927), Babcock (1927), Dickson (1936), McVay and Anson (1938-42), Goinard (1939), McClure and Fallis (1939), Amendola (1941), Neuhof (1942), and Harkins *et al.* (1943) have used this structure, and been satisfied with its importance in the repair of hernias of this region.

THE REPAIR

The technique presented herein has been developed and tested on 162 inguinal hernias of all types. To date there have been no recurrences. At the time this work was started we were not aware of McVay's operation.

Unless contraindicated, all of our herniorrhaphies are done under spinal anesthesia. Regardless of the type of hernia to be repaired, a skin incision is made as originally described by Bassini, clamping the superficial vessels before they are severed. The aponeurosis of the external oblique is cleaned of all fat and areolar tissue by sharp dissection, and a small incision is made in the direction of the fibers of the external oblique, near the upper margin of the wound. The incision is carefully enlarged with scissors until the ilioinguinal nerve is exposed and dissected free, and the iliohypogastric nerve is identified. (Damage to these nerves may result in an annoying skin anesthesia and a loss of tone of the internal oblique and transversus abdominis muscles, favoring a recurrence of the hernia.)

The incision is then extended down through the external ring and, with a moist gauze sponge, the aponeurosis is cleaned down to its insertion. The pubic tubercle is clearly identified and all areolar tissue is cleaned from it with a sponge. The sheath of the cremaster muscle is not opened, but is detached from the inguinal ligament with a moist sponge. After the cord has been mobilized, it is held with an Allis forcep, if small, or with a rubber tape if large enough to be constricted by an Allis.

The indirect sac is identified and picked up at the anteromedial surface of the cord. It is incised and freed from the surrounding structures by sharp and blunt dissection. Exploration is carried out through the incision in the indirect sac for a direct sac, and if one is found it is transposed lateral to the epigastric vessels, converting both sacs into one (Hoguet). It is necessary to identify the inferior epigastric vessels and to separate some preperitoneal fat from the indirect sac and to visualize and dissect the bladder away from a large direct sac before dissection of the sac is complete. Failure to do so may result in a recurrence of the hernia. The sac is closed with a pursestring suture and usually transfixed under the transversalis fascia and internal oblique muscle, although this step may not be necessary if the sac dissection is complete.

In order to avoid subsequent confusion in the identification of the structures used in the repair, the internal abdominal oblique muscle is identified and held with an Allis forcep. This step avoids later inadvertent suture of the muscle and its aponeurosis to the deeper structures.

Next, Cooper's ligament is palpated as a tough, ridge-like band extending from the pubic tubercle along the iliopectineal line (Figs. 1, 2). The transversalis fascia is then separated from the inguinal ligament and the underlying lacunar ligament in the area adjacent to the pubic tubercle by means of a small straight forceps (Fig. 3) and the anterior 2 centimeters of Cooper's ligament exposed (Fig. 4). Unless this separation is carried out close to the pubic tubercle the transversalis fascia will be entered and preperitoneal fat encountered, so as to interfere with subsequent suture (Trowbridge).

Further digital separation of the transversalis fascia from the inguinal ligament exposes a tough fibrous structure, the iliopubic tract, and the underlying femoral sheath (Figs. 4, 5, 6). By clearly exposing the iliopubic tract and mobilizing the femoral sheath, a procedure not previously described in the literature, we avoid accidental injury to the femoral vein or artery (Figs. 2, 5).

Gallie transplants of fascia lata, obtained with a Masson fascia stripper, are preferred to any other suture material for recurrent, direct, and scrotal indirect hernias. When fascia lata is used, the first strip (1 centimeter wide and 15 to 20 centimeters long) is anchored into the periosteum and tough structures overlying the pubic tubercle (Fig. 7). From this point a continuous running fascial suture is used. Henle's ligament is then brought down to Cooper's ligament. Next, the Gallie needle is passed successively through Henle's ligament, Cooper's ligament, and the medial portion of the iliopubic tract, closing the weakened area in the transversalis fascia, the site of most recurrent hernias. At the same time, the iliopubic tract is displaced, shortened, and drawn diagonally across the area occupied by the femoral canal, to close the canal (Figs. 1, 2, 3, 7). This procedure is technically less difficult than suturing the aponeurosis of the transversus abdominis to Cooper's ligament in the relatively inaccessible region of the femoral vein (McVay, 1942) and permits clear visualization of all structures used in the repair. The suture is continued (Fig. 7), attaching the lowermost margin of the aponeurosis of the transversus abdominis to the iliopubic tract, folding under and obliterating the relatively weaker areas of the transversalis fascia. When the internal abdominal inguinal ring is reached it may be closed tightly without endangering circulation of the cord. The end of the fascial strip is then anchored with interrupted No. 40 cotton sutures.

The same technique is employed in less difficult repairs with interrupted No. 20 cotton sutures.

This repair of the transversalis fascia and its reinforcing structures produces a strong barrier to recurrence of hernias. While there may be no necessity for further repair of overlying structures (McVay *et al.*); on the other hand, in most cases it is a very simple procedure to suture the lowermost margin of the internal abdominal oblique muscle and its aponeurosis to the inguinal ligament, by means of a fascial strip or interrupted No. 20 cotton sutures, after the method of Bassini (Fig. 8). We do not hesitate to use muscle for this second layer when the aponeurosis is deficient. Dissections of recurrent hernias have convinced us that the epimysium of the muscle will become firmly adherent to the inguinal ligament. Occasionally it is found that the anomalous aponeurotic insertion of the internal abdominal oblique muscle cannot be easily approximated to the inguinal ligament. In that event a relaxing incision in the rectus sheath is made (Rienhoff) and the fascia overlying the pyramidalis muscle, the lateral border of the rectus sheath, and available fibers of the internal abdominal oblique and its aponeurosis are then sutured to the shelving margin of the inguinal ligament. Either method of suture produces an additional strong barrier, and although we feel that the second layer is the least important of the two, nevertheless, the Bassini operation has cured many thousands of cases. Therefore, we have used this additional precaution.

The aponeurosis of the external oblique is repaired loosely over the spermatic cord, and the external inguinal ring is not made unduly small. We do not believe that the aponeurosis of the external oblique can be of much significance as a barrier to recurrent hernias, once the posterior wall of the inguinal canal has broken down.

SUMMARY

With certain anatomical facts as a basis for a rational reconstruction of an inguinal hernia, the described operation was devised. It completely closes the weak area superior to the pubic tubercle and posterior to the external abdominal inguinal ring. The salient features are:

1. By separating the loosely attached transversalis fascia from the inguinal and lacunar ligaments at their most inferior portion (close to the pubic tubercle), and stripping the fascia from the ligaments, a strong band of fibers is exposed, the iliopubic tract (Figs. 3, 4, 6).

2. As an initial step, Henle's ligament and adjacent portions of the aponeurosis of the transversus abdominis are sutured to Cooper's ligament along its anterior one-third, an available surface of approximately 2 centimeters. This results in no undue tension, whereas, suturing these structures to the entire length of the ligament, namely, back to the area of the femoral vein, does result in a definite tension and requires a relaxing incision in the rectus sheath.

3. The weak area of the transversalis fascia is further strengthened by attaching the transversus abdominis aponeurosis to the iliopubic tract as far as the internal abdominal inguinal ring (Fig. 7). This produces a strong pleat of transversalis fascia and raises and displaces the iliopubic tract closing the former defect (Fig. 7). At the same time this step produces a tight internal abdominal ring and closes the femoral canal.

4. A second barrier may be constructed by suturing the aponeurotic lower fibers of the internal oblique muscle to the inguinal ligament after the method of Bassini. If this aponeurosis should be deficient, a suture in the rectus sheath or in the aponeurosis of the transversus abdominis is taken, medial to that described in paragraph 3, and this layer sutured to the inguinal ligament. Rarely is a relaxing incision in the rectus sheath required.

5. The aponeurosis of the external oblique is repaired loosely over the spermatic cord, and the external abdominal inguinal ring is not made unduly small.

6. Strips of fascia lata have been found to be the most suitable suture material for the repair of recurrent, direct, and large scrotal indirect hernias.

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EARLY POSTOPERATIVE RISING

A Statistical Study of Hospital Complications

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THERE has recently been a revival of interest in early postoperative rising and walking. In June 1942 a critical study of early postoperative ambulation was undertaken at the Peter Bent Brigham Hospital. The preliminary results of these studies are the basis for this communication.

Ries in 1899 was the first to report on the subject of early postoperative rising. He had noted that his gynecological patients who rose from bed shortly after operation were considerably stronger, that as a group they had a low incidence of postoperative complications, and that there were no demonstrable ill effects of early rising. The early rising technique was not then widely accepted in this country, but in continental Europe it has been extensively used from 1909 until the present time. The recent revival of American interest in this subject began in 1941 when Leithauser (4) reported a series of 436 cases. Newburger (5) has published an excellent review of the American and foreign literature on the subject and also experimental data of his own (6) from rats. Newburger's experiments showed increased strength in wounds of animals in the early postoperative period if they had been given postoperative exercise. Clinical papers have been published by Leithauser (3), Nelson, Nixon, Powers, D'Ingianni, and Schafer and Dragstedt. All these authors are impressed by the rapid return to full strength of their early rising postoperative patients and by the apparent early reduction of wound discomfort. Almost all of them note a low incidence of pulmonary complications and of deep phlebitis of the legs. The latter three reports are the only ones in which any comparisons are drawn between a series of early rising patients and a control series. The definition of what constitutes early rising has not been very strict as some authors include in this group patients who have risen as late as the 4th or 5th day after operation.

In order to arrive at an accurate appraisal of the results of early rising, cases must be compared under as similar circumstances as possible. Since the incidence of pulmonary and vascular complications appears to vary in different parts of the country, the results of an early rising series in one region cannot properly be compared with those of a control series from a different region. The two series are most accurately comparable if they are observed in the same clinic.

From the Surgical Clinic of the Peter Bent Brigham Hospital, Boston, Massachusetts.

METHOD

In order to emphasize any apparent changes in postoperative complications, this study is limited to the type of operative case in which the complications most commonly occur; that is, patients having major abdominal surgery. Only patients who rose from bed either on the first or second postoperative day are considered in the group of early risers. These are compared with patients who remained in bed at least 1 week after operation.

This study compares 238 consecutive cases in which early rising was practiced with 443 in which it was not. The factors considered as possibly bearing on the incidence of complications were: (1) age, (2) sex, (3) type of anesthesia, (4) type of incision (upper vertical, lower vertical and McBurney).

The operations performed through upper abdominal incisions were on the biliary tract, stomach, duodenum, and spleen. The operations through lower incisions were on the small and large bowel, female internal genitalia, and occasionally the appendix. The procedures through McBurney incisions were all appendicectomies. The suture technique was that of interrupted fine silk to all layers except the peritoneum where continuous chromic catgut was used.

The complications studied were: (1) pulmonary (atelectasis, pneumonia); (2) vascular (phlebitis, pulmonary infarct); (3) wound (disruption, infection).

Our technique of getting the patients up from bed is modeled after Leithauser (4). The patient is turned upon the side on which he has his incision. The hips and knees are flexed. Thus the knees and lower legs are brought to the edge of the bed. The patient is then raised sideways to a sitting position on the side of the bed. The advantage of sitting up in this manner is that as the patient assists in raising himself, he uses the flank muscles on the side opposite from his wound. As the patient sits on the side of the bed his shoes are

TABLE I.—ANALYSIS OF COMPLICATIONS IN EARLY AND NON-EARLY RISING PATIENTS

	First day rising		Second day rising		Non-early rising	
	No.	Per cent	No.	Per cent	No.	Per cent
Total patients	185		53		443	
Complications						
Pulmonary	9	4.9	4	7.5	35	7.9
Atelectasis	8	4.3	3	5.7	28	6.3
Phlebitis	6	3.2	1	1.8	8	1.8
Infarct	3	1.6	0	0	2	0.4
Fatal infarct	1	.54	0	0	1	0
Wound disruption	2	1.1	1	1.8	12	2.8
Wound infection	5	2.7	0	0	25	5.7
Pneumonia	1	.54	1	1.8	7	1.6
Died	1	.54	1	1.8	10	2.3
Postoperative day of discharge						
7th–10th day	62	33.0	15	28.0	61	13.7
11th–13th day	57	31.0	16	30.0	56	12.6
14th–16th day	30	16.0	13	25.0	141	30.8
17th day plus	35	19.0	9	17.0	180	40.6

put on, and then he stands up on a foot stool[1]. While standing on the foot stool, he is encouraged to breathe deeply and to cough several times after deep inspiration. This procedure is less painful than when the patient coughs in bed and is often effective in raising mucous plugs from the bronchi. He is now encouraged to walk 8 or 10 feet before sitting in a chair. On the first rising the patient remains in the chair about 10 minutes, and then returns to bed in the same manner as he rose. Our patients were gotten up twice each day. Usually by the third or fourth day they needed little or no assistance and could rise at will. All the patients were encouraged to move freely about in bed and to breathe deeply several times each hour.

RESULTS

The most striking effect observed in early rising patients is the rapidity with which they regain their strength. In point of fact, they do not seem to *lose* strength. They are more active in bed, and their wounds are less disabling. On the fourth postoperative day most of the early rising patients had very little wound discomfort and got up unassisted. At this time they became ambulatory patients and required very little nursing care. As a result of this early strength and freedom from pain, most of the patients requested that they go home earlier than the non-early rising patients. We did not feel justified in sending our patients home before the seventh to ninth postoperative day because not until then could we consider that the time for appearance of wound infection or disruption had passed. In spite of this, 64 per cent of the early rising patients were discharged before the 13th postoperative day while only 26 per cent of the control group were discharged by this time. At the time of discharge, those of the early rising group were strong and able to do a great deal for themselves in contrast to the group who had remained in bed for 10 to 14 days and were usually discharged 1 or 2 days after getting out of bed.

[1]We have considered it important to put on the patient's shoes, or slippers with heels, before he bears weight as a prophylaxis against deep phlebitis of the leg veins. If the patient is one with short heel cords, he might injure his posterior calf muscles by standing, stepping down from the foot stool, or walking, and a pathological sequence could be initiated that might result in deep phlebitis.

INCIDENCE OF COMPLICATIONS

Table I lists the overall incidence of complications. The complications in the patients who rose on the second day are separated from those who rose on the first day so that a more accurate picture will be given. As this study was begun, we were concerned lest there be a marked increase in the incidence of wound disruption among the early rising group. It is seen that instead of increased incidence of wound disruption, the early rising group had a slightly lower incidence of wound disruption. Likewise the incidence of pulmonary complications was reduced. The incidence of vascular complications, however, was somewhat increased. None of these increments are, as yet, significantly greater than the standard error of their difference, but they point the trend. The trend

TABLE II.—ANALYSIS OF PULMONARY COMPLICATIONS

	First day rising							Non-early rising						
	Number	Pneumonia		Atelectasis		Total		Number	Pneumonia		Atelectasis		Total	
		No.	Per cent	No.	Per cent	No.	Per cent		No.	Per cent	No.	Per cent	No.	Per cent
Incisions (abdominal)														
Upper	84	1	1.2	8	9.5	9	11	198	5	2.5	20	10	25	13
Lower	45	0	0	0	0	0	0	154	0	0	7	4.5	7	4.5
McBurney	56	0	0	0	0	0	0	91	2	2.2	1	1.1	3	3.3
Sex														
Female	118	1	.8	6	5.1	7	5.9	301	2	.7	13	4.3	15	5
Male	67	0	0	2	3	2	3	142	5	3.5	15	11	20	14.2
Anesthesia														
Ether	133	1	.7	6	4.5	7	5.3	408	6	1.5	26	6.4	32	7.8
Spinal	39	0	0	2	5.1	2	5.1	19	0	0	1	5.3	1	5.3
Local	10	0	0	0	0	0	0	14	1	7	0	0	1	7
Age														
12–30 yrs.	63	0	0	0	0	0	0	125	4	3.2	7	5.6	11	8.8
31–60 yrs.	88	1	1.1	5	5.7	6	6.8	232	1	2.3	12	5.2	13	5.6
60 yrs. plus	34	0	0	3	8.3	3	8.3	86	2	2.3	9	10	11	12.8

toward earlier discharge from the hospital is seen in the greater percentage of the test group who were discharged early. This reduction in hospital days required and the fact that the patients who have risen early need less care represents a definite reduction in work for the ward personnel.

Pulmonary complications. The diagnosis of atelectasis was made in our patients on a clinical basis, if there was a postoperative rise in temperature associated with râles and elevated respiratory rate in the absence of other demonstrable cause for fever. The diagnosis was also made if there was x-ray evidence of atelectasis. The incidence in the first day rising group was 4.3 per cent, 6.3 per cent in the late rising group.

Table II is a comparative chart of the pulmonary complications analyzed for their various etiological factors. The familiar greater incidence of atelectasis in upper abdominal vertical wounds is seen in both groups when the cases are divided with respect to the location of the abdominal wound. It is significant that no case of atelectasis occurred in the cases with low abdominal wounds who rose on the first day.

Analysis for the sex factor shows that although the incidence of atelectasis in men who remained in bed was high, it was unusually low in those who rose on the first day after operation. The incidence of atelectasis among the females of the two groups is essentially the same.

The analysis for the type of anesthesia shows no significant variation in the incidence of atelectasis in either group whether ether or spinal anesthesia was used.

The influence of the age factor repeats the familiar pattern of increasing incidence of atelectasis with advancing age in both groups.

Pneumonia was such an infrequent complication that it does not permit comparative analysis.

Vascular complications. The term phlebitis is used in this discussion to include both silent thrombosis (phlebothrombosis) and deep phlebitis of the legs. The diagnosis of deep leg vein phlebitis was made on the basis of tenderness in the calf muscles, associated usually with one or more other signs i.e. a positive dorsiflexion (Homans') sign, edema of the lower leg, or a rise in pulse rate, temperature, or white count. Also if a patient had pulmonary infarct or embolism in the absence of heart disease, a presumptive diagnosis of phlebitis was made. The overall incidence of deep vein phlebitis among the early rising patients is seen to be *greater* than among those who did not rise early (3.2 per cent vs. 1.8 per cent). See Table III.

Analysis of the incidence of phlebitis with respect to the placement of wounds shows that there was no phlebitis recorded in any of the McBurney incisions whether they rose early or not. The females had a higher incidence of phlebitis than the males in the first day rising group. The highest incidence of phlebitis in the non-rising group was in the patients of 60 years or more, but in the early rising patients, the highest incidence was in the group between 30 and 60 years.

TABLE III.—ANALYSIS OF VASCULAR COMPLICATIONS

	First day rising					Non-early rising				
	Number	Phlebitis		Infarct		Number	Phlebitis		Infarct	
		No.	Per cent	No.	Per cent		No.	Per cent	No.	Per cent
Incisions (abdominal)										
Upper	84	4	4.8	2	2.4	198	5	2.5	1	0.5
Lower	45	2	4.4	1	2.2	154	3	1.9	1	0.6
McBurney	56	0	0	0	0	91	0	0	0	0
Sex										
Female	118	6	5.1	3	2.5	301	4	1.3	1	0.3
Male	67	0	0	0	0	142	4	2.8	1	0.7
Anesthesia										
Ether	133	5	3.8	3	2.3	408	8	2	2	0.5
Spinal	39	1	2.6	0	0	19	0	0	0	0
Local	10	0	0	0	0	14	0	0	0	0
Age										
12–30 yrs.	63	1	1.6	1	1.6	125	0	0	0	0
31–60 yrs.	88	5	5.7	2	2.3	232	1	0.4	0	0
61 yrs. plus	34	0	0	0	0	86	7	8.1	2	2.3

This observed increase in the incidence of postoperative deep phlebitis of the legs is not great enough to be of irrefutable statistical significance. But it is significant that our data do not agree with many of the previously published clinical impressions that early rising produces a reduction in the incidence of phlebitis. Early rising is apparently not the answer to the problem of postoperative venous thrombosis.

WOUND COMPLICATIONS

Considerable interest was attached to the possibility of increase in wound disruption which might occur from the increased stress put upon the wound in rising from the bed and walking about. Wound disruption is here defined as any wound in which the fascia is shown to have separated whether or not the peritoneum remained intact. Our data (Table IV) show an actual *reduction* in

TABLE IV.—ANALYSIS OF WOUND COMPLICATIONS

	First day rising					Non-early rising				
	Number	Wound infection		Wound disruption		Number	Wound infection		Wound disruption	
		No.	Per cent	No.	Per cent		No.	Per cent	No.	Per cent
Incisions (abdominal)										
Upper	84	4	4.8	2	2.4	198	11	5.6	8	4
Lower	45	0	0	0	0	154	4	2.6	2	1.3
McBurney	56	1	1.8	0	0	91	10	11	2	2.2
Sex										
Female	118	4	3.4	1	0.8	301	14	4.6	3	1
Male	67	1	1.5	1	1.5	142	11	7.8	9	6.3
Anesthesia										
Ether	113	4	3	1	7	408	25	6.1	12	2.9
Spinal	39	1	2.6	1	2.6	19	0	0	0	0
Local	10	0	0	0	0	14	0	0	0	0
Age										
12–30 yrs.	63	0	0	0	0	125	10	8	3	2.4
31–60 yrs.	88	4	4.5	1	1.1	232	13	5.6	7	3.0
61 yrs. plus	34	1	2.9	1	2.9	86	2	2.3	2	2.3

wound disruption in the test group. Among early rising patients there was 1.1 per cent of wound disruption whereas in the non-rising patients, there was 2.8 per cent incidence of wound disruption. The known higher incidence of wound disruption in upper abdominal incisions was demonstrated in both series. The two McBurney incisions that had wound disruption were those in which drains had been used.

The incidence of wound infection among the early rising patients was 2.7 per cent as compared with 5.7 per cent in the patients who rose late. This group includes all types of infection including stitch abscesses.

It is interesting to note that all of the wound infections in both series appeared in patients with potentially contaminated wounds. Of the 5 patients who had infected wounds in the early rising group, there were 4 patients who had cholecystectomies and 1 patient who had an appendicectomy for acute appendicitis. Of the 25 patients who had infected wounds in the non-early rising group, 11 had appendicectomies, 10 cholecystectomies, 1 a perforated ulcer and 3 a resection of the large bowel.

EVALUATION

We have now observed the technique of early postoperative rising for 3 years. Data on a control series of intra-abdominal operations are presented herewith. The most remarkable observation is that postoperative activity tends to maintain the patient's strength and endurance whereas prolonged rest leads to increasing weakness and muscle atrophy. It also appears that muscle activity in the region of the wound has the tendency to reduce the period of wound tenderness but it does not increase the incidence of wound disruption.

Early rising appears to reduce the incidence of postoperative atelectasis. This may be due to increased respiration and more effective coughing, especially when the patient is standing when his diaphragm can descend to lower levels (3). Since atelectasis most frequently appears during the first 48 hours after operation, the patient should be gotten up as soon as possible within that period if rising is to have a significant effect on preventing atelectasis.

In our experience[1], the incidence of phlebitis or phlebothrombosis of the deep veins in the legs is not reduced by early postoperative walking. Our data agree with the published impression of D'Ingianni who observed early rising patients in New Orleans. There may be certain precautions which can be observed to minimize calf muscle trauma when patients rise from bed. These are, however, equally important at any time in the postoperative period.

There was no greater incidence of wound disruption and infection in our patients who rose early.

SUMMARY

A controlled, preliminary study of early postoperative rising and walking is made on patients having major intra-abdominal surgery. A total of 681 cases were analyzed for postoperative complications and their causative factors. Early rising is defined as rising and walking on the first or second postoperative day.

The patients who rose early were considerably stronger and had less pain in their wounds. They were able to care for themselves on about the fourth postoperative day and were ready for discharge considerably earlier than the control group.

The incidence of wound disruption and wound infection was reduced in the early rising group.

The incidence of pulmonary complications was somewhat lower in the early rising group.

The incidence of deep leg vein thrombophlebitis was observed to be somewhat greater in the early rising group.

[1]It might be postulated that some of the late rising group developed signs of phlebitis of the leg veins at home several days after discharge. If so, it has not been apparent in the follow-up visits which are made 10 days to 2 weeks after discharge.

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EDITORIALS

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RESTORATION OF CONTINUITY VERSUS CURE IN CARCINOMA OF THE RECTUM

THERE is a widespread revival of operations designed to preserve the rectal sphincter in patients with carcinoma of the rectum and rectosigmoid. This aim to preserve the sphincter is a natural outcome of advanced surgical skill and technique, on the one hand, and, on the other, of evidence that primary spread of disease from this region is cephalward. At this time, we must carefully weigh the evidence of experience and adopt a rational attitude regarding the problem.

Given a patient with carcinoma of the rectum, we must take into consideration the single fact that cure, if possible, is our obligation. Unfortunately, many of these victims arrive in an uncurable condition—a fact due mainly to our inadequate educational methods, although, at the moment, there seems to be no effective manner in which all cases can be diagnosed in an early state.

In a recent series of 100 consecutive patients with carcinoma of the rectum the average duration of disease before entry into the Massachusetts General Hospital was 7 months. Twenty-eight had such extensive disease that a resection was impossible. Seventy-two had an abdominoperineal resection in one or two stages. There were two deaths in this group,—a postoperative mortality of 2.8 per cent. One patient died from hypertensive heart disease, and the other of a pulmonary infarct. About 10 per cent of the resections were done in the presence of hepatic metastases. Including the operative deaths, approximately 45 per cent of the operable cases or 30 per cent of the entire group will live 5 or more years. It appears at this time that only earlier diagnosis will materially improve these results.

The best, safest, and most adaptable operation so far devised is the combined abdominoperineal resection of Miles. The Miles technique may be varied in many ways and the operation may be done in one or two stages. This method allows the surgeon to remove the local spread of the disease including the regional lymph nodes and extension to neighboring viscera as well as to perineal muscles. In skilled hands, the mortality rate is low and the morbidity is growing less with better preparation and after-care. This procedure, however, does leave the patient with a permanent colostomy.

Colostomy is not burdensome to thousands of grateful individuals who have been cured of cancer. With reasonable care, they are free to carry on their business, athletic and

social functions, without offense or inconvenience. Sentimental abhorrence of the colostomy by patient and physician has wasted many useful lives. Although none looks forward to a colostomy life with avid joy, few will refuse it if the entire situation is explained to them. Taught the simple principles concerning care of the colostomy, nearly all of these patients are comfortable and happy.

In performing resections with low anastomosis, one must consider the following rules governing a proper operation for malignant disease. First, have we given the individual patient his greatest chance for cure? Second, have we increased his immediate hazard? Third, will the morbidity from poor sphincter control or fistula formation justify the procedure? The second and third of these have been pretty adequately answered in a satisfactory manner. The first concept is not yet determined and it will take considerable time to do so. In reporting results on these procedures, surgeons must make it clear that local recurrences have not taken place in those patients whom they would have expected to cure by performing a complete extirpation of the rectum and the muscles of the perineal floor.

The issue is confused by the fact that all of us agree that restoration of continuity is justifiable if the patient has metastatic disease in the liver at the time of operation. These cases should not be considered in the same light as those whose spread of disease was limited to the resectable area at the time surgery was undertaken.

ARTHUR W. ALLEN.

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

THE book entitled *Penicillin in the Treatment of Infections*[1] by Keefer and Anderson presents in its 42 pages a clear summary of what is known of penicillin and its effect, but it does not disclose any new facts about its action or administration.

Penicillin seems to act like the sulfonamides by interfering with some metabolic processes of susceptible bacteria and, therefore, is active only when the bacteria are in a phase of growth and multiplication. In the concentrations that are achieved in living beings its effect is chiefly bacteriostatic and not bacteriocidal. Thus it does not actually eliminate the infecting organisms but inhibits their growth and multiplication. But unlike the sulfonamides, penicillin is not inhibited by pus, peptones, or the breakdown products of tissue autolysis. The sensitivity to penicillin varies with the various species of organisms. It is not understood yet why gram negative bacilli and virus infections are not susceptible to the action of the drug, nor why susceptible bacteria may become resistant when exposed to the drug for longer periods. However, it has been shown that certain bacteria of the coli group produce a substance, penicillinase, which inactivates penicillin. The sensitivity of any bacterial strain to penicillin can be determined and may be very useful in the treatments of certain infections. Of considerable importance is the fact that there is no correlation between resistance to penicillin and resistance to the sulfonamides.

Several biological assay methods for determining the concentration of penicillin in the blood and the body fluids are available. It has been found that 60 per cent of the amount of penicillin injected in the blood stream or the muscles were excreted in the urine within 1 hour and that little or no drug remained in the blood after 3 hours. For this reason, it became evident that the use of large doses of the drug was wasteful since a better bacteriostatic level could be maintained in the blood by the administration of small doses given every 2 to 3 hours. It has also been shown that when mixtures of penicillin in beeswax and peanut oil were injected intramuscularly, the drug was absorbed slowly and the therapeutic effect could thus be prolonged to 6 or 7 hours. The authors recommend for the treatment of systemic infections the intermittent intramuscular administration of penicillin. Intermittent intravenous injections or continuous intravenous or intramuscular infusions offer no advantages and are considerably less convenient.

The passage of penicillin from the blood into the cerebrospinal fluid or the various parts of the eye is minimal and noneffective. Its passage into the pleural, abdominal, and synovial cavities is somewhat more satisfactory. It is therefore recommended to inject penicillin directly into the subarachnoid space, the cerebral ventricles, the articulations, the pleural cavity, the cranial sinuses, the chambers of the eye, etc. Topical application of penicillin to superficial burns, skin infections, and infected wounds by means of wet dressings or rubber catheter has given excellent results. The dosage and the most adequate way of administration are discussed for the various methods of administration of penicillin, and the clinical aspect of penicillin therapy is presented with more details in cases of staphylococcic bacteremia of the face, acute hematogenous osteomyelitis, chronic osteomyelitis, staphylococcic pneumonia, multiple subcutaneous abscesses, hemolytic streptococcal pneumonia and empyema, gonorrhea, meningococcemia, pneumococcic pneumonia, pneumococcic meningitis, subacute bacterial endocarditis, gas gangrene and syphilis. The toxic reactions are rare, the more common being urticaria and fever.

Penicillin is without doubt the most effective agent for the treatment of infectious diseases. However, it should not replace or diminish strict surgical asepsis, the early surgical treatment of wounds, and general medical prophylaxis against infectious diseases.

GEORGE PERRET.

AMONG the noteworthy publications of the Medical Department of the United States Army *Pathology of Tropical Diseases*[2] by Ash and Spitz will find a place in the first rank. It fills a need not met by textbooks on tropical medicine, which rightfully place emphasis on etiology, clinical findings, epidemiology, diagnosis, and treatment. This atlas, which is a collection of 941 photographs, photomicrographs, roentgenograms, and drawings, offers visual material in highly acceptable form. It is obvious that the authors had a wealth of material at hand, because nearly every illustration is one of the best possible. The technical quality of the reproductions is uniformly good. There is no doubt but that the publisher took the greatest pains to make this book as nearly perfect as he could.

[1] PENICILLIN IN THE TREATMENT OF INFECTIONS. By Chester S. Keefer, B.S., M.S., M.D., Sc.D. (Hon.), and Donald G. Anderson, A.B., M.D. New York, London, Toronto: Edited by Henry A. Christian, A.M., M.D., LL.D., Sc.D. (Hon.), F.A.C.P. Hon., F.R.C.P. (Can.) Oxford University Press, 1945.

[2] PATHOLOGY OF TROPICAL DISEASES; AN ATLAS. By J. E. Ash, Colonel, M.C., U.S.A., and Sophie Spitz, M.D., C.S., A.U.S. Philadelphia and London: W. B. Saunders Co., 1945.

Nearly every disease to be found in the tropics, from ainhum to yellow fever, is dealt with. Brief explanatory notes which include enough information to orient the reader, and sketches of the epidemiological facts are provided. The salient features of each disease are presented in excellent photographs or x-ray pictures.

This is an authoritative book. Although atlases are often thought of as supplementary works this particular one is outstanding because it is a highly intelligent contribution designed specifically to illuminate where illumination is most needed. It is recommended to students of tropical medicine and to pathologists who will be confronted with the sequelae of tropical diseases. HENRY R. JACOBS.

A LONG standing gap has been filled by Thomas' and Haddan's *Amputation Prosthesis*[1] by bringing together two authorities who have combined their knowledge to present a practical guide for surgeons and practitioners on the proper use of prosthetic appliances. This dual authorship—a surgeon and a manufacturer of artificial limbs—provides a common ground for discussion of the problems of the amputee.

The mutilating injuries of war have awakened an increased interest in amputations, surgical technique and prosthetic appliances. It has been estimated that the number of amputations resulting from the First World War totaled 500,000 for all nations engaged. Amputations among the armed forces of the United States were relatively small, however, numbering only about 4,000. During the Civil War there were well in excess of 30,000 amputations in the Union Army alone. Figures for the Second World War, released as of July 1, 1945, reveal that over 15,000 amputation cases have been treated in the various amputation centers established by the Army and Navy of the United States, and no doubt there will be many more before the toll of the war is ended. The total number of amputations resulting from World War II will probably exceed a million.

The number of amputations performed each year among the civilian population of this country far exceeds amputations performed in the armed forces, even in wartime. The American Federation of the Physically Handicapped has estimated that there are approximately 75,000 new amputation cases in this country every year, and that of this number 40,000 are major amputations requiring prostheses. The National Safety Council has reported that, prior to World War II, 32,500 amputations resulted annually from accidental causes alone. Reliable estimates reveal that there are now approximately 925,000 amputees living in the United States. The artificial limb manufacturers of this country report that prior to the present war they were supplying prostheses to more than 70,000 persons annually.

[1]AMPUTATION PROSTHESIS; ANATOMIC AND PHYSIOLOGIC CONSIDERATIONS, WITH PRINCIPLES OF ALIGNMENT AND FITTING DESIGNED FOR THE SURGEON AND LIMB MANUFACTURER. By Atha Thomas, M.D., F.A.C.S., and Chester C. Haddan. Philadelphia, London, Montreal: J. B. Lippincott Co., 1945.

In the past, too little attention has been paid by surgeons to the problem of the artificial limb, which the amputee must wear throughout life. As a result, amputations rarely have been considered from the prosthetic point of view.

There is a great need for closer co-operation between the surgeon and the limbmaker. Occasionally and unfortunately, surgeons, through lack of information, fail in advising the patient as to his permanent prosthesis or in supervising its fitting. Few surgeons are familiar enough with prosthetic appliances or limb fitting to give such advice.

There is a definite need for a practical text devoted to the amputation prosthesis. Such a text, to be of value, should be concerned primarily with principles of fitting and aligning the prosthesis and with instructions as to its use. In this book, the surgeon and limbmaker have collaborated, combining the scientific knowledge and training of the surgeon with the mechanical skill and practical experience of the limbmaker in order to give to the physician and the limbmaker alike a practical manual on the selection, fitting, and use of artificial limbs.

In the construction of the amputation prosthesis, emphasis is placed on simplicity of design and lightness of weight with durability. Materials used are important only insofar as they are light and durable and lend themselves readily to the necessary adjustments of alignment and fitting. The choice of materials often will vary according to the individual needs of the amputee, depending upon such factors as the site of amputation and the age, sex, occupation, and physical condition of the amputee.

Elaborate and complex joint mechanisms and control, despite extravagant claims of manufacturers and salesmen, are not essential in the average prosthesis. They add considerably to the original cost, are more difficult to adjust and repair, and offer few, if any, advantages over the more simple standard types. The ordinary amputation prosthesis is really a very simple apparatus mechanically, and if it is properly aligned and fitted it fulfills its functions most satisfactorily without complicated mechanisms.

Of far greater importance than materials and types of joint mechanisms in the successful use of a prosthesis are the *proper alignment and fitting of the limb*. This requires considerable skill, based on experience and judgment, and a thorough understanding of certain fundamental anatomic and physiologic principles. Surgeons and limbmakers alike have been too prone to place undue emphasis on the importance of materials and complex mechanical devices, neglecting the all important principles of alignment and fitting. In this text considerable attention is given to these fundamental principles.

Both the surgeon and limbmaker should guard against unwarranted claims and against encouraging ill founded hopes on the part of the amputee.

One chapter of the text pertains to prostheses for children—a subject which presents certain special problems and which heretofore has been given little or no attention in surgical texts.

A chapter is also devoted to the subject of the rehabilitation of the amputee. Particular emphasis is placed on the importance of the emotional readjustment of the amputee to his handicap. Attention is directed also to the necessity for instruction and training in the proper use of the prosthesis. Vocational guidance and selective placement in employment are also emphasized. Consideration of these problems, so often neglected, are of the greatest importance in the successful rehabilitation of a person handicapped by the loss of an extremity.

Special acknowledgment is given to Captain Henry Kessler, M.C., U.S.N.R., for use of photographs and diagrams demonstrating his cineplastic amputations and illustrating postoperative care of the stump preparatory to fitting the prosthesis, as well as for his valuable contribution on the subject of rehabilitation of the amputee.

The text covers the following subjects: development of modern amputation prostheses; the amputation stump; prostheses for amputations of lower extremity; alignment and fitting of lower extremity prostheses; upper extremity prostheses; prostheses for children; and rehabilitation of the amputee.

In comparison with some widely publicized contributions on the same subject, the reader will find the present volume a pleasant relief. The book is remarkably practical throughout. The illustrations are unusually instructive.

PHILIP LEWIN.

AS a result of his deductions from a study of the embryology and comparative anatomy of the stomach, the author of *The Muscular Build and Movements of the Stomach and Duodenal Bulb*[1] finds that the human stomach consists of four parts. Each part is homologous with each of the four stomachs of ruminants. He suggests that the fornix of the human stomach is homologous with the rumen and the corpus with the reticulum (second stomach). These constitute the longitudinal stomach. The transverse stomach which is usually referred to as the pars pylori, beginning at the incisura, he divides into three parts. The "sinus" fans out downward from the incisura forming the "knee" or "elbow" on the greater curvature. The "membrana angularis" fans out upward from the junction of the sinus with the pyloric canal, to form a bulge on the lesser curvature between the incisura and the pyloric canal. Thus, the "sinus" and "membrana angularis" form what is frequently referred to as the pyloric vestibule, and the pyloric canal, called the "pyloric antrum" or "prepyloric region." The duodenal bulb appears to be correlated with the pyloric sphincter, which structure contains a duodenal as well as a gastric component.

His anatomical description of the arrangement of the muscular fibers in the stomach in relation to the pyloric portion of the stomach and sphincter is enlightening.

The book is recommended to all students of the anatomy and physiology of the stomach.

ARTHUR J. ATKINSON.

[1] THE MUSCULAR BUILD AND MOVEMENTS OF THE STOMACH AND DUODENAL BULB, ESPECIALLY WITH REGARD TO THE PROBLEM OF THE SEGMENTAL DIVISIONS OF THE STOMACH IN THE LIGHT OF COMPARATIVE ANATOMY AND EMBRYOLOGY. By John Torgerson. Oslo, Norway: Fabritius & Sonners Boktrykkeri, 1942.

CORRESPONDENCE

BLOOD AMYLASE ACTIVITY IN PANCREATITIS AND OTHER DISEASES, A SIMPLE DIAGNOSTIC AID—A Correction

IN the February, 1946, issue of SURGERY, GYNECOLOGY AND OBSTETRICS a correction should be made in the captions for the color insert which appears opposite page 115 in the article entitled "Blood Amylase Activity in Pancreatitis and Other Diseases; A Simple Diagnostic Aid" by David Polowe. In row C the third figure should be labeled ++± (2½+).